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ABSTRACT

The theoretical basis of various aspects of curriculum development, and the innovations and changes occurring in the secondary school science curricula in Turkey are presented. The technical details of the curriculum development process are examined by means of an experimental study conducted to develop a unified science curriculum for the junior high school by the Turkish Science Curriculum Development Group (SCDG). The scope, planning, procedures, evaluation, and implementation of this curriculum are detailed. An outline of the subject matter units of the integrated junior high curriculum is provided. Instructional materials, learning activities, and test items from a unit entitled, "Change, Motion, and Time" are presented. A listing of the individuals who contributed to the curriculum development activities of the Science Curriculum Development Group concludes this publication. (BT)

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INNOVATIONS AND CHANGES IN SECONDARY SCHOOL SCIENCE CURRICULA

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TABLE OF CONTENTS

	Page
FOREWORD	
I. WHAT IS CURRICULUM?	
A. Curriculum Defined	14
B. Educative Process and Curriculum	16
C. From Subject-matter to Curriculum	19
II. DYNAMICS OF CURRICULUM DEVELOPMENT	24
III. INNOVATIONS AND CHANGES IN SECONDARY SCHOOL SCIENCE CURRICULA	
A. The Eight Year Study Movement	31
B. The «Alphabet Courses» Movement	35
C. New Direction for School Science Curricula for the 1970's	42
IV. A CASE STUDY — INNOVATIONS AND CHANGES IN SECONDARY SCHOOL SCIENCE CURRICULA IN TURKEY	
A. School Science Curricula Before World War II	47
B. The After War Period and Impact of «The Alphabet Courses» Movement	49
— Period of Sporadic Experiments	50
a. The Multi-purpose Jr. High School Experiment ..	50

	Page
b. Istanbul Atatürk Girls' Lycée Experiment	52
c. The Ankara Bahçelievler Lycée Experiment	55
d. The Teaching of Physics by Films Experiment ...	57
— The Impact of «The Alphabet Courses» Movement and the Science Lycée Experiment	60
a. Time Allocated to Science and Mathematics Teaching and the New Curricula	63
b. Changes Related to Content and Content Organization	64
c. Curriculum Innovations	65
d. Appraisal of the Science Lycée Curriculum Movement	69
C. Science Curriculum for the 1970's in Turkey	80
V. A SAMPLE WORK — DEVELOPMENT OF A UNIFIED SCIENCE CURRICULUM FOR THE JUNIOR HIGH SCHOOL	
A. The Need for a New Science Curriculum	82
B. Analysis of the Input and Output Characteristics and Formulation of Broader Aims	85
C. Subject-matter Selected and Instructional Units Developed	
D. Other Curriculum Materials Developed	97
E. Trial Teaching and Evaluation of the Curriculum Prepared	100
REFERENCES	
APPENDICES	
Appendix I — Excerpts from Instructional Units ...	115
Appendix II — Excerpts from the Teacher's Guide ...	129
Appendix III — Sample Items from the Units Achievement Test	142
Author Index	149
Subject Index	151

FOREWORD

The notion of curriculum and its practice in the educative process through schooling historically are very old. Systematic and experimental appraisal of curriculum patterns, however, is a new practice which has been accelerated during the last two decades.

The first organized, orderly and comprehensive effort in curriculum innovations and changes took place in the U.S.A. between 1932 and 1940, and is known as «the Eight Year Study». The anticipated impact of this significant movement was shadowed by World War II; and the expected chain-reaction in school curricular changes and innovations had not taken place. It was not until the mid-1950's that a new movement, which is totally independent from the former, came into being, again in the U.S.A. The latter was not only independent from the former, but was also different from it in scope and impact. It was born as a means for re-establishing the observed deficiency in the supremacy of the Western world over the Eastern world in sciences and technology which was caused by the after-war period; and gave impetus to the creation of the most profound changes and innovations in school science curricula. Absorbing the sporadic curricular activities of the early 1950's, it spread like a prairie fire, first in the U.S.A. after the mid-1950's, then all over the world during the 1960's and afterwards. The first products of this movement are known as «the alphabet courses» - e.g., PSSSC Physics, BSCS Biology, SMSG Mathematics, etc. While several countries organized their own curriculum development groups and experimented with various science

curriculum projects first at high school level and later on at lower levels of education; others involved in translation or adaptations of the alphabet courses into their school systems. Today there have been approximately 250 curriculum development projects in school sciences and mathematics conducted all over the world.

Around 1970 this movement has reached its peak in terms of number of studies of the similar character, and with respect to the rate of its acceleration, and has led the way to the creation of activities aiming at unifying the existing independent science curricula around new synthesis as interdisciplinary studies. In the meantime, due to the changes of the national priorities observed in the leading countries the beginning of another movement in science curricula has been witnessed. The basic philosophy of this last curricular movement in school science is not «more and better science for all», as was the ultimate aim of the previous movement, but «investigation of man-science and environment equilibrium to prevent the destruction of the environment by over developed and over utilized technology.» This last movement has resulted from the reactions based on the so-called «scarcity law» which requires re-examination of the characteristics of school science curricula for the establishment of a new interdisciplinary synthesis around «scientific exploration of man-environment interactions for the survival of mankind in the years to come.»

Caught in the midst of the international flood of the curricular changes and innovations of school science, sporadic activities of Turkey in school science curricula was immediately absorbed and like other developing nations, she adapted herself into the movement by importing the alphabet courses in her science education. Due to the ever existing time lag between advanced and developing societies with respect to innovations and changes in school science curricula, Turkey, like a good many other developing societies, continues to concentrate all her resources on realizing the already modified aim, «more science and better science for all», in her school science curriculum development activities.

In this work we ventured to investigate as systematically as possible the nature of different curriculum movements by giving dominant characteristics of some representative projects in school science curricula both at international and national levels. We have

first attempted to explore the concept of curriculum and process of curriculum change by means of different approaches employed for inducing changes and innovations in curriculum. Following this theoretical discussion, general characteristics of curricular activities in school science are examined first on the international scene, then in Turkey.

Finally, a rather technical exposition of the curriculum development process has been given on a sample work concerning the developmental phases of a unified science curriculum in detail. The appendix includes ample excerpts from the sample work on unified science curriculum.

A. Kemal Özlönü

I. WHAT IS CURRICULUM?

The term «curriculum» has had varying connotations which changed as education as a discipline of study has changed and developed through the history of mankind. As a result of the historical evolution of education, not only the concept of curriculum was changed and modified, but also the structural patterns of curricula have changed with it.

When different disciplines of study included in philosophy have become independent disciplines, and subsequently when psychology has gained independence, pedagogy could no longer survive as a field of study constructed by mere empiricism and speculation. Thus, under increasing impact of psychology, the conclusions and generalizations of pedagogy which had resulted from speculations and empirical judgments lost their validity and reliability. This has led to drastic changes in both content and method of pedagogy. The very first sign of the impact of psychology over pedagogy was seen as the loss of faith in the centuries-old learning theory which is known as «faculties of learning». This, in turn, induced value changes attributed to different disciplines of study which constituted the courses of study within school curricula. And relative importance given to different courses included in the school curriculum has been modified.

The impact of sociology on pedagogy came much later. Although the works of Herbart and Kant¹ on the relation between pedagogy and moral education laid the foundation for the construction of

an awareness of the social end of education; it was under the impact of pragmatic philosophy and mostly by the influence of John Dewey and his disciples that pedagogy changed into education; and education has gained a deliberate sense of social direction. This way education has come to function as a socializing and professionalizing process, rather than an avocation which is essentially aimed at developing the individual for his own sake as defended and believed by Rousseau and Pestalozzi². This newly adopted dual function of education has given leadways to significant curriculum innovations and changes. A careful examination of the definitions of curriculum given below will shed light on the exploration of the impact of changes occurring in the functions of education, on the establishment of different connotations and conceptions of curriculum.

A. Curriculum Defined

In the **Dictionary of Education**, curriculum is defined as «(1) A systematic group of courses or sequence of subjects required for graduation or certification in a major field of study; (2) a general over-all plan of the content of specific materials of instruction that the school should offer to the student by way of qualifying him for graduation or certification or for entrance into a professional or vocational field; (3) a body of prescribed educative experiences under school supervision, designed to provide an individual with the best possible training and experience to fit him for the society of which he is a part, or to qualify him for a trade or profession.»³

According to Anderson, Grim and Gruhn,⁴ «curriculum consists of the experiences that pupils have under the direction of the school. It is the school's job to plan worthwhile experiences. ... Definitely the curriculum **is not** the inert material in the pages of a course of study. It is the things children do, plan, write, read, construct, talk about, react to, and think about. It includes their field trips, their extra-class experiences, their student council activities, the study of community that they make, their farm projects in connection with their agriculture courses, their work experiences under school supervision. All these are significant learning experiences planned by the school to further the growth

of the pupil.» The **course of study**, according to the same source, «is a more limited term than curriculum, since it refers to the outline, bulletin or written plan that serves as a guide to the experiences that the teacher will plan for, and with, the pupils.»

It is seen from the aforementioned definitions that: (1) the courses of study and curriculum are different means of education; (2) courses of study have no definite sense of social direction, yet curriculum consists of a series of activities required for over-all development of the learner while he is equipt with skills necessary for a vocation or profession. The order in which curriculum is defined in the **Dictionary of Education** is the order from the courses of study to the curriculum.

The Lees⁵ in their book titled **The Child and His Curriculum** consider curriculum as an instrument which is utilized for the over-all development of the child through socializing processes. The Lees see curriculum as a series of goal-directed actual experiences. According to the Lees, experiences should be so selected and guided that they result in a socialized human being, they insure the development of democratic skills, attitudes, and procedures in the pupil, they make provision for the individual differences in children, they result in mentally and physically developed, emotionally mature individuals, capable of adapting to the needs of the local community. Although in this conception of curriculum the role of education as assisting individuals to be adjusted members of the local community is considered to be fundamental, adjustment to the society at large, however, has not been significantly evaluated. This may be due to the fact that the Lees had elementary education as their center of activity for the investigation of curriculum.

Morrison (1940), on the other hand, is very much content-oriented in his definition of curriculum as he says, «curriculum is the content of instruction without reference to educational ways and means». ⁶ It is readily seen that this definition lacks means and ends relations in the process of education, and emphasized only the acquisition of the content of different disciplines of study without considering their reason for existence in the process of education.

In the 1950's, an Illinois group composed of Smith, Stanley and Shores included clearly the social dimension in the concept of curriculum by stating that curriculum is «a sequence of potential

experiences... set up in school for the purpose of disciplining children or youth in group ways of thinking and acting». ⁷ In this definition, the term «discipline» is perceived in Dewey's conception of discipline ⁸, «thinking and acting» as referents of behavior modifications to be stated in measurable terms; «group» refers to both community and society at large.

Beauchamp (1956) refers to curriculum as «... the design of a social group for the educational experiences of their children in school.» ⁹ It is not very clear from the definition, however, on what criteria the design of experiences are constructed, and what forces effect the patterns of such design.

In the light of the aforementioned definitions and discussion we can at least state that there exists a dynamic interrelationship among such social and educational entities as: (1) culture and curriculum; (2) targets of educative process and societal demands; (3) the nature and targets of the educative process and individual needs; (4) the targets and educational experiences to be selected from culture; culture, subject-matter and the educative process; (5) culture and subject-matter as the collection of disciplines of study; (6) the educative process and curriculum; (7) ways of validating the curriculum by means of the quality of the product of the educative process. The dynamics of the interaction pattern existing among such elements is investigated below as relations between the educative process and curriculum; and as a process of curriculum development.

B. Educative Process and Curriculum

Any attempt to explore the concept of curriculum would be without a foundation if it does not expose curriculum within the context of the educative process. Fundamentally education is an instrument for social stability and social change. While education changes society, society simultaneously induces changes in education. Therefore, there is a bilateral interaction between society and education. In centrally planned societies the existence of this bilateral interaction is readily seen in their short and long term developmental plans.

It has been observed that in Russia, for instance, and in some other centrally planned societies, educational reforms and curricular changes generally precede the anticipated changes in social structure. In societies with free enterprise economic systems, interaction between social structure and education is latent, more complex and more gradual.* In order to visualize the nature of «the educative process» and the position of curriculum within it, we shall very briefly discuss the interaction between society and education.

How does education maintain stability in society and yet induce changes in it at the same time? Education maintains stability in the society by means of cultural transmission and changes society by changing, although indirectly, the culture of society. In an oversimplified version the process of interaction may be broken down into the following stages:

1. Education takes its raw materials from the culture of a society in consideration.
2. It creates an optimal milieu for maximum interaction between this raw material and those to be educated in social institutions called «the school».
3. During the stage of the optimization of interaction, society may further change and develop, due to the innovations and discoveries realized within that society or imported from relatively more developed societies as the alternatives of its culture. Now if school fails to revise the raw material that it took from the culture, a time-lag would be born between society and the school. Thus the school would utilize the relatively older culture as its raw material, and thus education very likely becomes incapable of inducing changes in society. If, however, the school continuously modifies the part of culture that it took from the society as has been

* As a matter of fact some studies — see for example the work of Christopher Jencks — do not support the existence of a bilateral interaction between education and society; they rather claim that it is the society which influences education and education can induce no fundamental changes in social structure with respect to the existing socio-economic stratification in a market-oriented society (Ref: 10)

modified and developed by the society; and at the same time creates innovations by means of its outputs as school graduates, the time lag is minimized: thus education induces changes in society through changing its culture.

In this process education is responsible for selecting the necessary experiences from the culture in order to create a milieu for optimal interaction. Thus schools function as agencies of education where the pattern of interactions are decided and are realized under controlled conditions. In doing so, education takes the immature as the input, processes it through predetermined interactive patterns and produces it as the mature member of society. Through this process, which we term «the educative process», the school functions as an agency which sorts and selects the input, while developing it. In this way, the school changes, modifies and develops the original behaviors of the input (the learner) and makes him: (a) socialized and (b) professionalized. When the input is processed and thus has become socialized, culture has been transmitted from the mature to the immature; and universally shared elements of culture* such as mores, folkways, commonly accepted beliefs and values are acquired by the input. If, however, society is in transition and some «alternatives» to the old know-how, beliefs, and values do exist within its culture, school interjects these alternatives into the behavior pattern of the input; thus socialized individuals would not only be capable of maintaining the stability, but also be capable of inducing changes in society through changing its culture.

On the other hand, the input acquires some know-hows termed as «specialties of culture» along with his socialization through the educative process. The relative weight of the specialties given to the input within the educative process depends upon the level of

* For elements of culture, see Ralph Linton's work, *The Study of Man*, where three fundamental elements of culture, namely: (1) the universals; (2) specialties; and (3) alternatives in culture are identified and exposed (Ref: 11); also the work of Sorokin on *Social and Cultural Dynamics*, where two pure cultural premises are identified, namely: (1) «ideational» which serves as the system of reference for validation of the «truth of faith», and (2) «sensate», which serves as a system of reference for validation of the «truth of sense»; and a mixture of the two pure premises, called «idealized» which is the system of reference for validation of «truth of reason». (Ref: 12)

education he is at, and that weight increases as we go up within the existing hierarchy of the school system. This way the input gains the necessary skills needed for his preparation for a profession or vocation; and thus the school functions as an agency where manpower demands of the society are met.

Now that we have exposed, even though very briefly, the dynamics of the «educative process» we may attempt to identify the place and functions of «curriculum» within that structure.

Although, as can be seen from the definitions given above, no consensus has been established among educators on the concept of curriculum, it seems to us that curriculum is a means in the educative process which affects the ends of the process. It possesses such functions as: (a) selecting the part of culture to be included in the instructional process as the raw material of the educative process; (b) translating that raw material into statements of behavioral objectives to be developed in the output; (c) determining the nature, intensity and duration of the interaction patterns to be utilized within the educative process; (d) controlling the quality of the outputs (the educated) through assessment, and accordingly suggesting modifications in the instructional process and/or in the target qualities of the output. Thus curriculum, even though it may function as a means in the educative process, is a dynamic entity all by itself. That is why when educational policy changes, curriculum changes accordingly. If the priorities of a nation change, then education is modified, the educative process is altered, and thus curriculum must be re-developed. When curriculum changes, the objectives, or the target behaviors of the output must be re-developed, reformulated. Changes in objectives induce modification in the instructional process. We shall have a closer look at the dynamic interrelatedness of the elements of curriculum in the later part of this chapter and in the next chapter.

C. From Subject-Matter to Curriculum

A curriculum constructor must decide what portion of culture should be included into the educative process. More specifically, if we assume that culture is the product of the mankind, we then have to consider that: (a) this product is continuously increasing; (b) it

may contain impurities — that is, undesirable residues according to the norms of humanity; ② and only some part of this product is in the form of an organized body of knowledge. All these qualities of culture require the curriculum maker to be selective. Thus, the part of culture selected for the educative process, in the form of an organized body of knowledge, is called the **subject-matter**. Subject-matter is then a unique raw material of curriculum which ties the curriculum with culture.

It is quite clear that the selection of the subject-matter is dependent upon what is expected to develop in the product at the end of the educative process. More specifically, if we are after having the product gain such qualities which require solely learning of knowledge that the existing disciplines of study can offer, then the subject-matter is biased and does not significantly represent the total culture. And in such a case the educative process, and likewise curriculum, have no deliberate sense of social direction. This is the era when the concept of «disciplining the faculties» reigned in pedagogy. It is in this particular case that the terms **curriculum** and **syllabus** became seemingly synonymous. This is so because, in this particular case, acquisition of the content of the disciplines of study is the sole objective of the educative process. This is when the term, curriculum, is out of focus and likewise is misused as in the cases of Lycee Curricula published by the Turkish Ministry of Education.*

To illustrate the difference between the conception of curriculum and syllabus their comparison based on some criteria is given below as it appeared in the **Encyclopedia of Educational Research**¹⁴:

* Publications by the Turkish Ministry of National Education under the title of *Lise Müfredatı* (High School Curriculum), 1960, 1964, are sufficient examples to clarify the misuse of the term, curriculum. (See Ref: 13.)

Criteria	From Syllabus	To Curriculum
1. Purpose of curriculum development	Informational and disciplinary	Concern for child growth and development; insight into contemporary problems; effective learning; teacher growth
2. Leadership in curriculum development	Subject specialist and college professors	Teachers, supervisors, psychologists, specialists, and parents working together
3. Methods	Armchair	Developmental and experimental appraisal
4. Content	Subject-matter to be mastered	Functional content and activities; subject-matter and experiences correlative
5. Appraisal	Subject-matter tests	Considerations of attitudes, appreciations, methods of work and thinking, ability to use facts in relation to behaviour

Now, let us turn to the dynamic model of curriculum. First of all, the model includes the following elements: society, community, culture, societal demands, socializing function of education, the manpower development function of education (economic dimension); the individual, individual needs, group and group needs; subject-matter; disciplines of study; the educative process as a system of interaction between the subject-matter, the learner, the learning group, the teacher and ways and means which are selected as to their degree of fitness for the realizations of expected changes of behaviors in the learner; and finally, the process of validating the educative process by means of measuring and evaluating the magnitude and the variety of changes which have occurred in the learner and in the class group.

How are these elements related to one another in the construct of curriculum? Can we identify cause and effect relations among these elements existing within the construct of curriculum? To simplify the case, let's attempt to formulate the interrelatedness among these elements on a diagram. (Figure - 1)

CONSTRUCT OF CURRICULUM

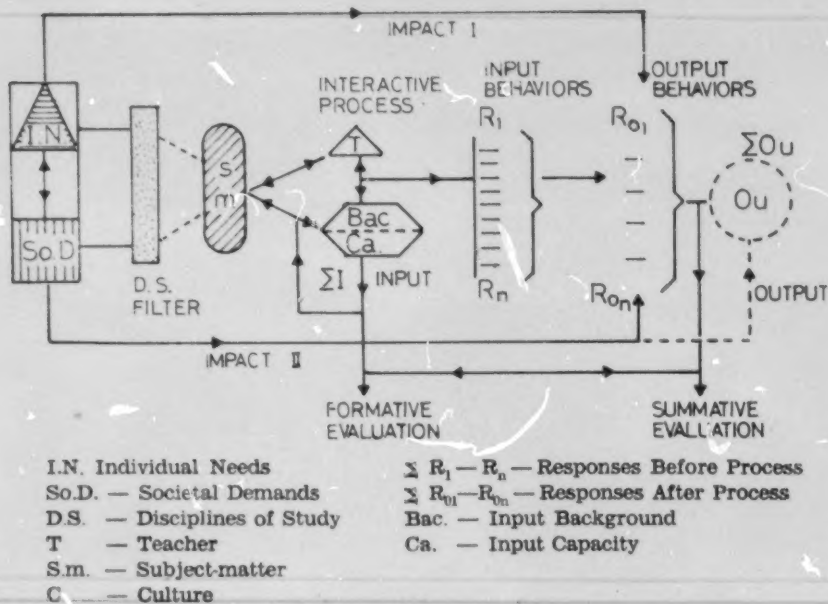


Figure — 1

In this model: (1) Society creates culture from which the societal demands are extracted. These in turn are filtered by a special part of culture called an organized body of knowledge and known as disciplines of study. At the end of this filtration process, impurities of culture both at the normative and cognitive levels are diffracted and thus the social portion of the subject-matter to be included into the educative process is identified, organized. (2) Individual needs go through a similar process of purification at the end of which portion of the subject-matter reflecting the individual needs is obtained. The proportion of these two elements of the subject-matter is the function of the socio-political and socio-economical system of the society. (3) Societal demands and the individual needs together determine the expected patterns of behavior of the individual. The degree of the realization of these

patterns are checked by the degree of closeness of the patterns of responses. (4) The teacher who values, and restructures the subject-matter according to the observed level of maturity of the child and the composition of the class group with respect to their background and capacities, plans, organizes experiences in the form of class and extraclass activities in order to optimize the interaction among the subject-matter, the learner and his classmates, and himself which will induce changes and development of their response system in the predetermined magnitude and direction. (5) Again the teacher, by measuring and evaluating the magnitude and the direction of that change re-adjusts the intensity of the aforementioned interaction by means of changing his ways and means. (6) If the repeated evaluation indicates that the product falls short to a considerable degree from the target behaviors, he questions the validity of the targets as well as the subject-matter.

II. DYNAMICS OF CURRICULUM DEVELOPMENT

In the preceding chapter, the concept of curriculum has been explored in relation to the educative process, where interrelatedness among culture, subject-matter and curriculum has been pointed out. All this suggests that the curriculum developer should be keenly aware of the forces operating within the existing culture, of the direction of social change and its reflection on the nature of subject-matter and content selection; identification of the newly emerging goals as shifts in the national priorities take place. It is also required that the curriculum developer should identify and formulate suitable learning experiences drawn from the modified subject-matter in order to insure synchronization between social change and curriculum revision. In order to induce, control and maintain changes in the educative process, thus in curriculum as caused by social changes, principles and techniques of social change may be successfully utilized. In that regard, the process of inducing, controlling and maintaining such changes may be referred to as «educational engineering»^{15, 16} and the curriculum developer functions as an «educational engineer».

Fundamentally, the primary step in deciding the selection of subject-matter is to determine the criteria by which the subject-matter selected would be validated. Since the subject-matter is to be utilized in arriving at certain patterns of behaviors as targets, the criteria to be utilized for validating the subject-matter will serve as the criteria to test the validity of the goals of education.

These criteria are: (1) desirability, (2) possibility of attainment, (3) measurability, and (4) consistency. By desirability is meant the degree of correspondence and relatedness between the subject-matter and educational aims with respect to fulfillment of the societal demands and satisfaction of individual needs. If society is in transition, the goals and the subject-matter selected for curriculum should be such that they would insure social reconstruction. In this particular case, more and more of the alternatives of the culture will be included into the subject-matter selected; and likewise the educative process would be directed toward targets which would help to develop in the output the ability to analyze, synthesize and critically evaluate.

This way, «desirability» criterion will filter out from the subject-matter as well as from the output behaviors everything which is not demanded by the society; and/or by the individual as their needs and interests. Yet, the criterion of «possibility of attainment» will function as a screening device which insures that the behaviors as reflected from the subject-matter would correspond to the maturity level of the input. It is by means of this criterion that educational experiences based on the subject-matter selected would be at the level of readiness of the learner.

The criterion of «measurability» reflects the importance of assessment in the educative process. As we shall see later in some detail, assessment is needed in every stage of the educative process. It is needed in the input stage in order to decide individual dimensions of desirability of both subject-matter and output qualifications. It is needed at the process stage as a measure of feedback to judge the effectiveness of the process in the form of formative evaluation.¹⁷ It is also needed in the form of summative evaluation to judge the quality of the output of the educative process. The only way to maintain such check-ups in the educative process depends upon the effective use of the «measurability» criterion. To insure this requires the formulation of targets of the educative process as the output qualities in behavioristic terms.

«Consistency» as a criterion for subject-matter selection and formulation of objectives is determined by the aid of systematic evaluations both formative and summative. If some experiences drawn from the subject-matter selected for the process, or some

behaviors formulated as the targets of the process when utilized or realized are not compatible with behaviors which are readily achieved, then one facet of the educative process is not in line with the others; or the nature of the process at t_1 time is contradictory to the nature of the process, and thus to the product of a later (t_2) time. Thus consistency insures optimization of the interaction pattern between the input and the experiences chosen for the process. Now, let us try to illustrate on a diagram how these criteria require interrelatedness among the input, the process, the output and the output qualities as objectives, and also assessment:

Let's suppose that a triangle represents the relations among input, process and output (See, Figure: 2). Let **I** stand for input, **P** for process and **Ou** for output, and let arrows ($\rightarrow$) indicate the direction of interaction. For simplicity of arrangement, and for

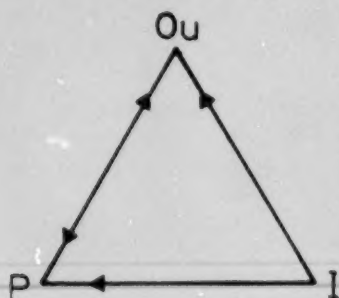


Figure — 2

deciding the point of departure, let's ask which of the three entities is predetermined and the most independent. As might be guessed, **I** is independent and predetermined.* Then neither **P** nor **Ou** will induce change in **I**. As a matter of fact, when **I** changes, **I** becomes processed and then it will become **Ou**. Therefore, no interaction can be thought of in the direction of **I**. Can **I** induce changes on **P** and/or **Ou**?

Is it possible that the nature of both **P** and **Ou** are dependent on the quality of **I**? The answer is affirmative; and therefore we can establish a unilateral interaction (action) between **I** and **Ou**, and **I** and **P**, as indicated by the single arrows.

How is the nature of the dependence between **Ou** and **P**? Does change in **P** induce change in **Ou**? Similarly, when **Ou** changes, does this change require modification in **P**? In both cases it means that when **Ou** or **P** changes, each induces changes on the other. Therefore,

* When only the original characteristics of **I** are considered. However, by same selective measures like «the track system» or entrance examinations changes may be insured in the input characteristics as demanded by the output qualities.

P and Ou are mutually dependent; and the relation between them is bilateral as indicated by the double arrows.

Now that we have established the nature of the interactions among process, input and output in the educative process, let's attempt to include «assessment» into that construct. For brevity and simplicity, let's again visualize their interaction pattern on a triangle.

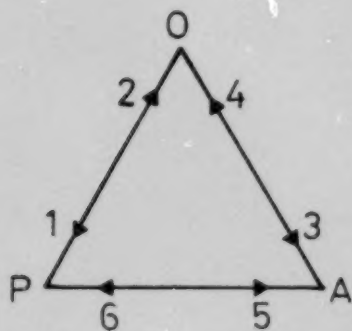


Figure — 3

This time we shall place assessment, objectives and process at the intersections of the triangle (Figure: 3), using A for assessment, P for process, and O for objectives. Let's again identify the point which is the most independent among the three, as the origin of constructing the pattern of interaction. We know from the earlier knowledge of the educative process that objectives and process are interrelated. That is to say, objectives determine the intensity and the variety of the process to be employed in instruction. Then we place an arrow indicating this relation (arrow No. 1). Since process includes the learning experiences selected from culture it is bound to modify objectives as the results of formative evaluation reflected on the input may deem necessary (Arrow No. 2). On the other hand objectives definitely determine the nature of assesment, and likewise assesment may induce changes in objectives, especially on their levels of possibility of realization. Therefore there is a bilateral relationship between O and A, as indicated by Arrows 3 and 4.

The results of formative evaluation used as feedback to determine the effectiveness of the instructional process, shown as Arrow No. 5, serves as the nature of the impact of A on P; while process P may set forth some prerequisites on A, which may modify the nature of assesment (Arrow No. 6). However, the intensity of impact in the latter is weaker than the former.

If we combine the two triangles we obtain a complete picture of the interaction pattern. As represented by (Figure - 4), in this system of interaction:

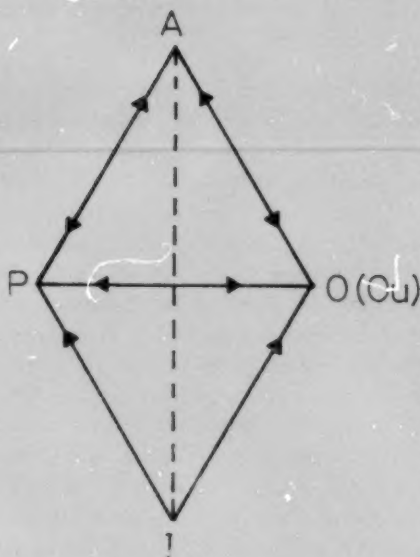


Figure -- 4

1. Both objectives (O) and input characteristics (I) determine the variety and the intensity of the instructional process.

2. Assessment aids exploration of (a) the input characteristics which are revealed as individual differences with respect to the background and innate capacities of the input; (b) effectiveness of the instructional process including the validity of the subject-matter selected by means of formative evaluation; (c) the pattern of behavioral change realized on the output which validates the possibility of their level of the objectives formulated.

Now, what is the significance of this pattern of interaction exposed for the construction and development of curriculum? The following may be deduced from the model of interaction exposed above for both curriculum development and curriculum construction;

1. Assessment is a strikingly important agency in curriculum construction without which neither the validity of subject-matter nor the desirability and plausibility of objectives, nor the effectiveness of instruction, nor the quality of the input or the output could be determined reliably. Therefore, both construction and revision of curriculum requires a careful use of assessment.
2. In order to make accurate and reliable assessment as needed for curriculum development, objectives must be stated in measurable or behavioristic terms. This makes it mandatory that both ultimate goals expressing the functions of education and intermediate aims which picture the desirable changes to be realized by the instructional process:

should be reformulated in behavioristic terms^{7,17,18,19,20,21,22} as objectives of instructional process in order to aid both the curriculum constructor and the teacher to receive meaningful messages about the efficiency of the work they do. There has been some significant development in the direction of formulation of educational objectives according to the criterion of measurability since the beginning of the pioneering work of the 1930s²¹, and its revision in 1946²¹ as contributed by the works of Cohen and Nagel²³, Dewey²⁴, Kessler²⁵; and by the most recent works of Bloom and his group.^{17,18}

3. In order to increase the reliability of the formative evaluation made on the instructional process, the subject-matter must be organized around units.
4. In order to meet the observed differences in the qualities of the input, alternative curriculum packages may be used as different approaches to the achievement of the same goal as is done in Project Physics curriculum²⁶, or by means of three versions of **BSCS Biology** and of special curriculum materials (SM) prepared by the BSCS group for lower-ability students.²⁷
5. Care must be taken to match, through different curriculum material packages, the input's individual characteristics with instructional process (e.g., individualizing the instruction by developing programmed instruction curriculum materials).
6. Plausibility of objectives can be determined through trial teaching of the curriculum materials prepared by effective use of formative evaluation results since the test results obtained from formative and summative evaluations are highly correlated.¹⁶ (p. 137)

Thus curriculum development is to construct a model which reflects some pattern of interaction between the input and the subject-matter through instructional process in order to attain targets formulated; and which involves ways of assessment and results of assessment of the intensity of this interaction as measured

by the amount of change occurred in the input after it becomes output.

Innovations and changes observed in school science curricula are discussed in the next two chapters in the light of the theoretical treatment given here in relation to the concept of curriculum and process of curriculum development.

III. INNOVATIONS AND CHANGES IN SECONDARY SCHOOL SCIENCE CURRICULA

Even if it is limited to the high-school level, examining historically world-wide science curriculum developments is a very wide and comprehensive undertaking that would be the subject of investigation of an entire study.^{28, 29, 30} We shall therefore concentrate our exploration around activities which had a significant impact on science curriculum at international level and which may be identified as a significant movement which induced wide-scale profound changes in the basic philosophy and application of science curricula at high-school level.

In our treatment of the subject, three of such basic curriculum development movements are identified, namely; (A) the Eight-year Study movement of the 1930's which was created under the guidance of the Progressive Education Association; (B) the «alphabet courses» movement of the mid-1950's and early 1960's which was developed by the influence of the leading American basic scientists aimed at the realization of «more and better science for the society», and; (C) the movement of the 1970's which seeks to re-establish «man-environment equilibrium» by means of school science.

A. The Eight Year Study Movement

The movement began in 1930 by the leadership of Progressive Education Association of America. There are indications that

economic crisis of 1930's caused the inauguration of the movement. It was the first nation-wide, organized effort concerning the development of the secondary school curricula, including science curriculum. It continued till 1940 and because of its duration it is known as «the Eight-Year Study».^{31, 32}

Following a long period of discussions and planning, thirty schools were selected from all over the country which served as the experimental schools of the study. The experimental schools began to utilize the freedom* given to them to make changes in their curricula by questioning the validity of functions and goals of secondary schools with respect to the degree that they reflected the changing demands of society and over-all development of the individual student.³¹ It is clearly seen that this movement was testing the validity of the philosophy of the child-centered movement reigned in the 1920's America. Thus, it was explored during the movement that two factors determined the direction of curricular change, namely: (1) the expectancies of the adult society, and; (2) the needs of youth.³¹ (p. 54) The experimental schools have made changes and innovations in their curricula in varying depth and breadth. While some induced drastic changes in their old college bound curriculum in the direction of exploration of society and basic human needs, others were more cautious and were satisfied with minor changes they made on their curricula based on college requirements. One of the outstanding contributions of this movement to the theory of curriculum change was in the area of assessment.

As it was noted earlier, the use of assessment systematically has not only resulted in the development of the concept of experimental validation of curricula developed but also established an awareness of need felt for the formulation of aims of curriculum in measurable terms as behavioristic objectives.^{19, 21} Similarly, the work of evaluation group under the leadership of Ralph Tyler has led to the development of reliable tools to measure changes resulted in the output after they are exposed to revised instructional processes of the revised or re-developed curricula. Measuring devices

* They were given freedom because their graduates would not be evaluated by college requirements in their admission to most of the leading colleges and universities.

included are: tests on aspects of thinking; consisting of the test of ability to apply the principles of science and logic, nature of proof, interpretation of data; a test on social sensitivity; a test on aspects of appreciation; and several questionnaires and achievement tests.¹⁹

Another noticeable contribution was the exploration and advancement it made with respect to the instructional process by developing «process units of instruction» where heavy emphasis was laid on the use of «problem solving and reflective thinking processes» as their basic activity as classroom strategy.³¹ It was in this respect that the Eight Year Study has made innovations in school science curricula, and the foundations it laid on the role of problem solving in teaching of science is still strong and very widely used even though under a modified name called «inquiry teaching».³² An excerpt taken from the curriculum of a community high school participated in the study illustrates the goals and content of science curriculum they developed and the philosophy underlying the relationship among science, technology, community life, human society and the development of the individual.³²

This course on «The Scientific View of the World and Man» includes the following features:

Imaginative association with great scientists is used as one effective way of learning about scientific methods. The history of science is full of adventure and dramatic action, which appeal strongly to young people's interests and arouse their imagination. The lives of some of the great scientists are studied, represented major scientific fields. These scientists are thought of as living men, facing with difficult problems to which they do not know the answers, and confronting many obstacles rooted in ignorance and prejudice. In imagination, the students watch them at work, and look particularly for the methods which they use in attacking their problems. They see them, in Pasteur's words, «constraining themselves for days, weeks, even years, trying to ruin their own experiments, and only proclaiming their discoveries after having exhausted all contrary hypotheses.» Thus the methods of science are thought as instruments which man have created and used to solve some of humanity's most important problems.

Some of the great scientific experiments are also studied, which are within the comprehension of tenth graders — experiments of recent years as well as of the more remote past. Whenever possible, these are repeated in the school laboratory. Students see how the experiments and discoveries of scientists have changed our ways of living, how

the work of Watt and Faraday made possible our modern systems of power machine production and rapid transportation, how experiments of Boussingault and Mendel led to scientific agriculture, and how Pasteur and Koch revolutionized the treatment of disease.

Students trace the development of the view that we live in a world of natural laws, of orderly cause and effect, not a world of chance or arbitrary action. They observe the growth of faith that human intelligence, using the scientific method of inquiry, can discover the laws of nature and so bring the physical world increasingly under man's control. They also see that science has given man the basis of the highest hopes for a better world.* For science not only makes possible, it also sets new goals for man to work toward.

Throughout the year, an attempt is made to add to the students' stock of fundamental scientific principles and facts and to help students to see these as related parts of a whole. Most boys and girls, the teachers have found, are now able to develop a conception of a natural universe, operating according to laws, and of themselves as parts of that universe. When once this pattern of thinking has been well established, other facts and principles are fitted into it as students continue to learn. (pp. 130-132)

The above passage clearly illustrates the efforts made to organize the content of the instructional units in accordance with the process of scientific inquiry, interest of the students, and developing values in students about positive contribution of science to social development. It also indicates that development of scientific thinking in the students, through content organization and by means of appropriate instructional processes was the aim of the science curriculum developed. All the qualities that this science curriculum possessed are still valid to-day.

We shall see how these qualities of school science curricula developed by the Eight Year Study movement are modified, developed or re-inforced by the movement called «the alphabet courses era» which is investigated in the following section.

According to the results obtained on a comparative analysis made on the college achievements of the graduates of the experimental schools, it was found that: (1) The achievement of the

* Consider how this faith in science has been questioned by the last science curriculum movement of the 1970's which is treated in the last part of this chapter.

graduates of the thirty schools was slightly higher than the control group with respect to both their group averages and their individual academic standing; (2) the graduates of the experimental schools where profound curricular changes were realized, were strikingly and significantly more successful than their pairs in control groups as compared to the experimental schools which did not change their curricula noticeably.³¹

B. The «Alphabet Courses» Movement

The second World War not only interrupted the possible impact of the Eight Year Study but also has changed the direction of the curriculum development movement. There are three criterion attributes of the after war period. The first is the increased importance attached to the projects concerning science curricula; the second is the shift of the power of contribution to the development of curriculum, from university educators to university basic scientists; and the third the rapid expansion of the movement which created a chain-reaction in curriculum change by spreading all over the world. The movement which began in the U.S.A. in the late fifties, continued intensively and with an accelerated pace after 1960.

The first product of that movement in its beginning stage is known as the «alphabet courses» of high school science and mathematics. They include Physical Science Study Group (PSSC) Physics of the initially Massachusetts Institute of Technology Group; Chem Study Chemistry (1963) of the Chemical Education Material Study Group of University of California; Chemical Bond Approach Chemistry (CBA) of Oregon Group; Science Curriculum Improvement Group (SCIG) Physics of University of California headed by Robert Karplus; Elementary Science Study (ESS) of Educational Services Inc. which was launched in 1960; Science - A Process Approach which began in 1963 by the American Association for the Advancement of Science (AAAS).

Great number of curriculum studies are of projects of a single discipline,^{34, 35, 36, 37, 38, 39} e.g. PSSC in physics, CBA or Chem Study in chemistry, BSCS in biology; Atkin group's in elementary astronomy; MSG in mathematics. Few others emphasize on process of science for example, Swartz's study at New York University on

measurement and experimentation⁴⁰ or AAAS' **Science - A Process Approach**.⁴¹ Some sporadic efforts aimed at the cultivation of scientific and logical reasoning, for example the project of Van Deventer;⁴² while only a very few pioneering projects involve ecological studies on «man-environment relations»,⁴³ or attempt to develop interdisciplinary syntheses in the form of a unified curriculum such as Introductory Physical Science (IPS)⁴⁴, an attempt to unify PSSC, and CBA by Portland Group.⁴⁵

At the beginning stage of the curriculum movement almost all of the projects aimed at science of the high school level. The studies directed to the lower levels of education came up at a much later date. According to the Clearinghouse Annual Reports published by University of Maryland, in 1970 there was a total of 246 curriculum development projects in school science and mathematics conducted in 36 countries of the world.⁴⁵ Of these studies, 115 have been conducted in the U.S.A. alone. As to the disciplines of studies, 49 studies were in mathematics, 36 in biology, 31 in chemistry, 6 in earth sciences, 34 in general and/or elementary science, 5 in physical science, 36 in physics, and 13 miscellaneous. The number of projects has increased by years from their beginning in 1956 up to 1970 and has reached its peak by then. Another movement was shaping up, after mid 1960's and has begun to creep into the scene of the science curricular activities. Presently this movement has developed into a recognizable magnitude and began to question the basic philosophy of the earlier curricular movement which aimed at «more and better science for all». As we shall see at the end of this chapter this last movement principally has targeted itself «to re-establish the balance lost between man and his physical environment which as claimed, was caused by heavy emphasis on science, and over-technology».

In order to illustrate the nature of the pioneering work accomplished by this first curriculum movement, below is investigated very briefly the curricula of PSSC as a sample of the alphabet courses produced during the first stage of the movement.

The Physical Science Study Committee, better known as PSSC, initially centered at the Massachusetts Institute of Technology (M.I.T.) led to the formation of Educational Service Inc., at Newton Massachusetts. Their first product, PSSC Physics was put into teaching in 1957-58, with 300 students and 8 teachers. In 1965-66

academic year the number of students rose to 200,000 which is about half of the students enrolled in physics classes in the U.S.A.⁴⁶ The curriculum package developed includes a textbook, a laboratory guide, simplified apparatus and experiment kits, films, achievement tests, books as reading materials on special topics, and a teacher's guide.

The **content** of PSSC Physics includes four major parts: concepts of time, space and matter as first part; the nature of light, covers the second part; motion in Part III; and finally electricity and atomic physics are treated in Part IV. In Part I works on measurement of time and space follows immediately the particle nature of matter where concepts of atoms and molecules are carefully presented. However, for the exploration of the dynamic structure of atoms students have to wait till the arrival of Part IV where electrical forces, waves and energy interaction leads to the consideration of electromagnetic radiation from which atomic structure of matter, including scattering experiments related to the establishment of a simple Rutherford atomic model is established. Here also, the particle-wave duality of light and matter is shown. Then, energy levels are explained in terms of standing wave patterns from where the content of PSSC Physics comes to a close with a quantum mechanical view. Both Part II which explores wave and particle models of light and Part III which deals with dynamics and Newton's mechanics lay a foundation for the exposition of the dynamic structure of matter which is given in Part IV.* All these illustrate that the content has a logical unity.

The **order of content** included in the subject matter is logical and chronological. That is to say topics when built on the top of the other increase in difficulty and complexity. Thus, the content has the order of «from elementary to complex».

The fundamental **strategy of teaching** that the curriculum materials suggest to be followed by the teacher is «learning by experimenting». There is no traceable indication, however, that the development of the problem solving ability of students is

* In later additions of PSSC Physics, Light was treated as Part I because it was felt that it would fit better to the interest of the student. (See Preface of the Third Edition of PSSC Physics.)

promoted and cultivated through content organization either in the text book or in lab experiments or in other educational technology developed by PSSC. On the other hand, it is seen that the class activities, laboratory work and the films are smoothly geared into one another.

Although the curriculum materials developed by PSSC were the result of the process of **experimental appraisal**, the effectiveness of the newly developed material have been evaluated by means of a few preliminary follow-up studies with small number of high school graduates who had been trained through PSSC Physics during their high school education.⁴⁷ The magnitude of this work is not at the level achieved by the Eight Year Study.

The following generalizations are given in order to illustrate the nature of the curriculum movement observed after World War II, and the philosophy behind the initiation and realization of that movement:

1. The after war era of curriculum movement in the school sciences was not the result of the increasing dissatisfaction with the old curricula rather it was the outcome of the changes of the public policy on nation's (America's) priorities which demanded more and better qualified scientific and technical manpower. The launching of Russian Sputnik in 1957 definitely contributed to the creation of public policy on science education in the direction of more and better science.⁴⁶
2. Science curriculum development groups organized by the mid 1950's were composed of man of science and science teachers rather than educators as was the case in the earlier practice.*
3. The content of the science curriculum developed was more discipline-centered, technology disoriented, chronologically organized, and was conceived as an explanatory system

* Even a quick examination of the members of study groups will reveal that both the attempt and the work were done by the basic scientists. See the composition of PSSC as an example where basic scientists contributed to the realization of the project.

where the order of the topics is from elementary into complex.^{31, 36, 37, 44} However, the curricula developed had the aim of presenting science «not simply up-to-date codification of the findings» of science but «as an unfinished and continuing activity».⁴⁷

4. The science curriculum developed **aims** meeting the needs of not only those students who would choose science-related fields as their future careers but also the students preparing themselves for fields other than science.⁴⁷ Thus the new curricula would stimulate the able high school student to continue the study of science at upper levels of education while it would help to develop an understanding of the importance of science by the so called «science-shy students» who will discontinue their science training after high school.^{27, 46, 47}
5. In the science curricula developed **laboratory activities** are considered to be an essential and a natural part of classroom learning. «Experiments-whether they are performed by the student, analyzed in the textbook, or shown on film - are not simply to confirm an earlier assertion»⁴⁶ rather «to introduce a topic; to supply firm rooting for the growth of ideas by providing direct, non-verbal contact with relevant data»⁴⁶ sometimes demanding qualitative and other times quantitative results. In this manner an insight into the role of experiment in the scientific inquiry and for the refinement of physical ideas would be developed by the student. In some cases, for example in BSCS Biology, laboratory works are organized around meaningful blocks of ideas each of which takes up a six weeks intensive work centered on a single area of biology. This way «....., it is hoped that the student will be able to drive a sense of the process of science, and the nature of scientific inquiry and discovery, and then he will learn why science requires precise measurements, accurate observations, ... and clarity in communication» so that he should develop an understanding of the significance of team work in the laboratory, «importance of experimental controls, and how hypotheses are developed and tested». All these, it is expected, would give him a readiness in scientific attitude

to the problems he may face in the adult life.⁴⁸ In the others, in CBA Chemistry for instance, laboratory works are organized around the effective use of problem solving strategy, on two different dimensions; (a) breadth, and (b) depth. For that a series of experiments are designed «to pose a problem for the student to solve with a minimum formal direction (breadth) to be connected with the text and with each other» (depth or vertical development).⁴⁹

6. The **teaching strategy** emphasized by the new curricula may be expressed as «guidance of learning activities based on laboratory oriented individual work where method of inquiry is promoted, sometimes with a clear intention other times with an unconscious effort». It is not unreasonable to state that the magnitude of conscious effort on the application of science as a process of inquiry as fundamental strategy of teaching increases from **PSSC Physics and Chem Study** to **BSCS Biology** and to **AAAS, Science - A Process Approach**. Although all of the science projects developed consider developing an understanding of scientific method and problem solving or inquiry ability as their primary aim; content organization in the text-books, and experimental designs in the laboratory and teacher's guides make no clear indication that the teaching-learning process are organized around problem solving activities except in CBA to some extent and definitely in **AAAS Science - A Process Approach** where the organization of teaching - learning units are directed toward such an end. In this particular curriculum project, the teachers' guides include specific recommendations of instructional procedures to be used in developing student ability to observe, measure, classify, infer and predict by means of interpreting the data collected through controlled experiments based on testing of hypotheses formulated. «The expectations is that the ability to use scientific processes will remain after many of the details of science have been forgotten.»⁴⁶
7. The **process of development** of the curriculum materials of the alphabet courses follows a somewhat similar sequence where: (A) a study group mainly composed of university basic scientists and some secondary science teachers is

organized; (B) this group normally functions as curriculum material writing team and thus after a preliminary discussion, it considers the nature and the aims of the work to be achieved; (C) writing team, after identifying the boundaries of the subject matter to be included in the curriculum, organizes the subject matter in the form of instructional units; (D) after the initial writing of some instructional units and having developed of the related educational technology - mostly experiment kits at this stage - the units are put on trial teaching with selected groups of students and teachers; (E) when all the instructional units are experimentally appraised and validated for their fitness for teaching and their effectiveness for achieving the expected objectives, final curriculum package which normally included: (1) A text book with a laboratory guide — implicate in the text or independent; (2) A series of supplementary reading; (3) A complete set of educational technology consisting of experiment-kits made with locally available materials, slides, charts, films etc; (4) A teacher's guide; and (5) Achievement Tests and other evaluation tools, are published.^{34, 35, 36, 37} Sometimes the first publications are considered as trial or preliminary editions. In such cases, final editions are published after the necessary revisions are made. Final editions, in general, are given to the sponsorship of a publishing company.

8. The **appraisal** of the new materials was done through: (A) Criticisms and suggestions of the secondary science teachers who participated in the experimental teaching of the course; (B) Observations of the course writing teams based on their visit to classes where experimental teaching was conducted; (C) Reactions of the students to the new materials as obtained systematically by questionnaires; (D) Results obtained on the achievement tests specifically designed for the new material.^{34, 35, 36, 46, 47} There has been no mention, however, if the achievement tests constructed on the targets selected are accurate enough to tell what specific behaviors, besides the knowledge and comprehension, of the students changed as the result of his interaction with the new curricula. In other words, since the objectives

of the new curricula had not been formulated in the form of taxonomical behaviors, the appraisal based on the achievement tests were global and hazy. For instance, rather low correlation was found between the scores of the students of CBA Chemistry on situational tests of problem solving and their aptitude scores on tests administered by Educational Testing Service.⁴⁶ «The results of the analysis of achievement test performance by students from various levels of academic aptitude, as measured by conventional aptitude tests, clearly suggest that success in handling the ideas of the PSSC course is not limited to a narrow band of what, by traditional measures, called high-aptitude students». There have been few preliminary studies «indicated that PSSC students were at no disadvantage» in their performance in college physics.⁴⁷

9. Despite of their contributions to the modernization of the content and teaching-medium of the school science, the most significant curriculum development projects were centered around independent disciplines of science which made their contributions limited to the structuring of compartmentalized curricula as it is found in the traditional subject curriculum. Unifying attempts came at a much later date after the full realization of curricula of independent scientific disciplines.

C. New Directions for School Science Curricula for 1970's

«Just a few years ago American science education was under the great impact of the Sputnik era of science, which caused creation of an acceptance of public opinion toward more science, and more number of scientists. American science education to-day faces, unconsciously as yet perhaps, the question of 'More science for what? Why more technology which brought us face to face with an ever increasing number of technological problems that it has created, and with a more polluted atmosphere, and with an environment which have been unbearably distorted and decayed, contrary to the expectancy of the mankind!' One may justifiably ask: Is the present American science education on the right track, or is it at a crossroads?.....»

The above excerpt taken from an article appeared in **Science Education** under the title of «Is American Science Education at the Crossroads?»⁵⁰ reflects the beginning of a new movement for school science education. Whether, or not, this last movement would receive an echo in school systems of world nations as has been the case with the movement of the alphabet courses is yet to be seen. However, there are signs coming from the curricular changes in universities where science curriculum specialists are educated that the new movement is becoming to shape-up. A closer look at the formulation of this last movement will reveal that the shift occurred in the national priorities of the technological advanced societies like the U.S.A.⁵¹; sluggish development in their economy; the over supply of basic scientists and engineers - more than what American society could absorb⁵² as resulted from the emphasis on «more and better science» inaugurated by the alphabet courses movement; and development of the public awareness about the harmful effects of over developed technology on the survival of the mankind⁵³ seem to be the chief reasons for that movement.

The pattern of formation of a movement of curricular innovations and changes given above may serve as a good example to illustrate the nature of interaction between cultural change and curriculum modification as was examined theoretically in Chapter 1. The formation of this last movement clearly indicates how new alternatives emerged in culture induce changes in policy of school education and likewise in school science education and how the policy change results in modification of the subject-matter selected and objectives formulated for science curricula. This reaction becomes an impulse for curriculum modification.

Let's us now explore what changes this last movement brought to the subject-matter and the content organization of science curricula by citing some examples from readily developed curricula on «man-environment interaction, and man-environment equilibrium».

Although it may be at college level, a course developed by Schlesinger on «Nuclear Power Generation and the Environment» may serve as a typical example to illustrate the content organization that is included into science curriculum under the impact of the new movement. Let us read:

«I designed a course using the Ft. Calhoun (nuclear power)* plant as a case study... (which) was first presented as a summer institute.

The academic content was organized in three component parts. The first part examined the physics of fission events, the engineering of efficient use of these events, the design and construction constraints imposed by the site, plus economic and regularity considerations.....

The second component dealt with possible environmental impacts, resulting from radiation and thermal effluents..... as they applied to the specific generating plant and to the river ecosystem in question.

The third component concerned the impact of social, political and legal factors on the plant's operation. While these are national «perhaps international» scope, they were focused upon Ft. Calhoun consciously and deliberately. The hearings conducted by AEC in Omaha were discussed at length.»⁵⁴

As the major units of the course content indicate, this is a multi-disciplinary course in which physics, economics, social sciences and biological science are integrated, or fused together. It is directed to develop an awareness in the students about man-technology — environment - society relations. Content organization is neither completely logical - in the sense that knowledge is organized from elementary to complex or from simple to difficult — not psychological — based on the interest of students; but perhaps problem oriented and socially phenomenological. Since it is a survey course, the effectiveness of its content organization with respect to the degree of change expected to insure on the students is yet to be seen. However, it clearly exemplifies the basic philosophy of this new curriculum movement.

There are sufficient examples that the ocean studies are becoming a part of many secondary science program.^{54, 56, 57} Thus, «the recent growth of marine science curricula may reflect an expanding public awareness of the significance of ocean phenomena to our everyday affairs.»⁵⁵ As a matter of fact, marine sciences including marine ecology is going to be a part of the curricular activities on environmental studies even in elementary and kindergarten education.⁴³

On the other hand there is a much wider use of the formulation of objectives in behavioristic terms as suggested by Tyler and

* Phrases in parantheses are mine.

Bloom.^{17, 18, 19} The use of multi-disciplinary content organization directed toward behavioristic objectives by the wider use of educational technology and individualized instruction organized in the direction of utilization of the process of inquiry may seem to be direction of course of development that the new movement may follow. The main impact and dominant characteristics of this last movement, however, will be much clearer by the end of 1970's.

In the next chapter the innovations and changes in school science curriculum of Turkey are investigated as a case study to explore the nature of echo that the science curriculum movements observed in technologically advanced societies made over the developing ones.

IV. A CASE STUDY - INNOVATIONS AND CHANGES IN SCHOOL SCIENCE CURRICULA IN TURKEY

While fundamental changes were induced by the Eight Year Study movement in the U.S.A., and by «the alphabet courses» movement in most of the technologically advanced societies, what is the impact of these movements on developing societies? In order to investigate the reflections of such curricular movements on science education policies and curriculum organizations of developing countries we took Turkey as a case and attempted to investigate the changes occurred in her school science curricula: (A) during the period before World War II; (B) under the impact of the «alphabet courses» movement, and; (C) in 1970's.

Turkey has a centrally run educational system. Changes and innovations in school curricula are induced by the National Board of Education. She has a mixed economy to which both private and public sectors contribute. Since the establishment of Turkish Republic, there has been continuous efforts to govern economy in accordance with developmental plans 3-5 years of duration. However, consistent use of developmental plans in the country began after 1962. Thus societal demands are explicitly stated in the developmental plans in terms of projected needs of manpower for various sectors of the country. Likewise general principles of education policy are formulated by means of the developmental plans.⁵⁸ Therefore, generalizations arrived below in relation to the changes and innovations observed in Turkish school science cur-

ricula should be evaluated within the context of this socio-economic frame.

A. School Science Curricula Before World War II

Since virtually no sources were available written in the new Turkish alphabet based on the Latin characters, the need for science text books at school level was met by means of a series of students hand books for Botany, Physics, Chemistry and Geology put out by the National Ministry of Education in 1929. The aim was to free students from taking notes during the lectures, rather than to provide them with supplementaries. These sources were written by a group of science teachers assigned by the central Ministry of Education; and were published ten thousand copies* of each source.⁵⁹

A closer examination of these sources reveals that the process of instruction and content organization were basically didactic. The targets selected for science curricula were the mastery of a scientific discipline at knowledge and comprehension levels without consideration of attainment of ability to extrapolate. Consciously or not the nature of instructional process and structure of a scientific discipline were thought to be identical in essence in this application.

By 1932, a new trend in science education was underway. The trend which lasted till the beginning of the World War II was more striking at the first cycle of the secondary school science than the second cycle. It was induced by the pre - the Eight Year Study movement of the U.S.A., since the books^{60, 61} which were used as the instruments of this curriculum innovation were adapted from text books of American origin.⁶² This attempt gave impetus to acceptance of individual development through social adaptation as goals of science curriculum in addition to help students to acquire facts and principles of science and to develop an ability to apply these principles into their daily-lives in solving problems of society by means of science and technology. This intension is clearly visible from the content selected as instructional units such as:

* This signifies the total number of students enrollments in science classes of the entire nation.

Unit I - The World We Live In; Unit II - Air and Climate; Unit III - How to Obtain Good Food; Unit IV - How to Obtain Good Running Water; Unit V - How to Remain Energetic and Healthy; Unit VI - Selecting and Taking Care of Our Clothing; Unit VII - Protecting Ourselves from Diseases; Unit VIII - The Nature and Control of Fire; Unit IX - Obtaining Hot and Clean Air in Our Buildings; Unit X - Construction Materials; Unit XI - Labor-Saving Devices and Machines; Unit XII - Making Use of Air and Water Power; Unit XIII - The Use of Steam and Explosive Gas; Unit XIV - Production of Electricity; Unit XV - Lighting Our Homes and Streets; Unit XVI - Communicating with Our Neighbors; Unit XVII - Land, Water, and Air Transportation.

As seen from the headings of the units, science and technology as its product are regarded as a tool for individual adjustment and social development. The syllabus of science curriculum is organized in accordance with the philosophy that science is needed for economic development and social adjustment of the individual, and therefore the content selected for science curriculum has become unavoidably technologically bound.

Since the Teacher's Guide which is supplemented to the English Version of the science book adapted was not translated into Turkish, the essentials of teaching processes to be followed which was Herbartian Formal Steps² in general, the ways of evaluation, the statement of objectives were not put into effect in the Turkish application. Likewise possible role of the guides in giving in-service training to the teachers who utilized the text books was not realized. This might have served as a source of pull back which negatively effected the dissemination of awareness among science teachers about what innovations that these new sources of science brought to the country's curriculum; and possibly prevented the support needed for prolonged use of this syllabus in the lower cycle of secondary education of the country, and also undermined the development of critical size of specialists needed for creative work in curriculum construction in school science.

As a matter of fact, the sudden change observed in the school science syllabus near World War II with respect to its content boundaries, content organization and goals, supports our view concerning the limitedness of the impact that the adapted curri-

culum had made on the school science. In 1937, it is observed that integration of curriculum around different disciplines of science such as chemistry and physics was abandoned. And each became an independent course in the study of science. Not only that scientific disciplines had become compartmentalized and thus isolated from one another, but their content organizations followed very closely the unique structure of a particular scientific discipline. Thus, units of instruction constructed around central themes aimed at the realization of long term social adjustment and individual development were completely abolished, a content organization based on logical order of «from elementary to complex» was adapted instead. The subject-matter selected was deductive, like those found in the student hand books⁵⁰ of 1929; perhaps a bit more systematic than those. This way a trend that was about to emerge in school science that headed toward the realization of such social aims suggested by John Dewey in his report that he wrote upon his visit to Turkey in 1924 as : (1) *to*^{*} form proper political habits and ideas; (2) *to* foster the various forms of economic and commercial skill and ability, and (3) *to* develop the traits and dispositions of character, intellectual and moral, which fit men and women of self-government, economic self-support, and industrial progress; namely, initiative and inventiveness, independence of judgement, ability to think scientifically and to cooperate for common purposes socially⁶³» was altered and thus died-off.

B. The After War Period and Impact of «the Alphabet Courses» Movement

Traditionally, the secondary school science education policy and likewise science curricula in Turkey, whether or not they may be affected by the current international curriculum movements, have been under continuous impact of two sets of forces, namely; the influence of educators, and the pressure of the university basic scientists and high school science teachers without sufficient background in professional education. While educators induce changes in the science curricula of the lower grades of secondary education in the direction to make the curricula more goal oriented for the

* Italics are mine

realization of social adjustment, and individual growth; the basic scientists on the other hand have been keenly interested to see that the school science curricula, especially the curricula of upper grades of secondary education must resemble to that of the unique structure of a particular discipline of study that is like the structure of physics, or chemistry both with respect to the content selected for the instructional process and to the organization of the content selected. This is clearly seen by the examination of the compositions of the subgroups of the National Education Conventions in charge of policy formulation and curricular changes and the documents they produce related to the curriculum development.^{13, 63, 64} Therefore innovations and changes which are examined in two stages as: (1) the after war period and, (2) the period under the influence of «the alphabet courses» movement should be evaluated together with the degree of the impact they have received from these two distinct sources.

The After War Period - Period of Sporadic Experiments

The school science curricula practically remained unchanged from 1937 to the beginning of the establishment of the Science High School in Ankara in 1964; except in sporadic cases where some experiments planned and conducted under the guidance of educators on high school curricula — including the science curriculum experiment which is planned, organized by the Ministry of Education in order to establish experimental comprehensive junior high schools. As we shall see clearer when we examine each experiment individually, the results of experiments have not reached the magnitude to induce nation-wide changes to mark the beginning of any movement in school science curricula. The period of sporadic experiments included, besides the experiment on establishing comprehensive junior high schools, Istanbul Atatürk Girls Lycée experiment, Ankara Bahçelievler Lycée experiment, «Teaching Physics by Films» experiment which are examined below.

a. The Multi-Purpose Junior High School Experiment

By an announcement appeared in the Ministry's official journal in 1953, Turkish Ministry of Education decided to establish experimentally multi-purpose junior high schools similar to the models found in the United States, England, Sweden and Belgium. This

way, it was hoped, such shortcomings as «heavy emphasis on academic learnings» observed in the regular junior high schools, «heavy academic and technical load and narrow specialization» observed in the technical vocational schools would be overcome; and a more democratic atmosphere would be created for the students in their three years of junior high school education.⁶⁵

The experimental Junior High Schools would have a multi-track curricula. «The academic track» would prepare students for higher academic learning as the regular Jr. H. Schools do; «Vocational line» would give boys education needed for a future vocation while the homemakers line would be designed for girls accordingly.

What was significant in these schools concerning science curriculum? For the first time an integrated science curriculum would be developed and it would be practiced in technical vocational lines. As a matter of fact the integrated science curriculum foreseen to be practiced in the experimental Jr. H. Schools has been nothing but a modified version of an integrated science curriculum designed and developed by means of «judgemental procedure»,⁷ for the first two years of the six-year Village Institutes and Normal Schools.⁶⁶

What are the unique characteristics of this unified science curriculum? The curriculum attempted to integrate physics, chemistry and biology under a single course titled «Natural and Physical Sciences». It had valid aims such as «to show students ways of examining nature, to teach the use of the scientific method, to teach them to comprehend the causes and effects of natural and scientific phenomena through the knowledge they have acquired and the methods they have applied». ⁶⁶ As seen from the statements given above, aims do not clearly identify what changes are expected in the student after he is exposed to the activities included in the new curriculum. For instance, it is not clear from the way the aims are formulated when the teacher teaches the learner «the use of the scientific method» will he be helping the student to develop his knowledge about the use of the so called scientific method or is the student expected to develop higher level cognitive and affective behaviors that are normally found in the scientists or in people capable of making discoveries. Thus fundamentally how valid and comprehensive they may have been even for present day, the ob-

jectives formulated are not measurable. The validity of the curriculum materials prepared could not be easily determined by way of assessment; despite the fact that some valuable suggestions are provided to the classroom teacher about appropriate ways and means to be used for the realization of the broader aims indicated above.⁶⁶

The syntheses developed in the subject-matter of the new curriculum by way of instructional units prepared conform to the characteristics of «the broad-fields curriculum.»⁷

Among instructional units developed there are some which reflect some kind of synthesis established on spatial-temporal relations and individual-society interaction such as «The Child and His Environment» and «Water and Its Effects». The majority of the instructional units, however, continue to possess the characteristics of independent disciplines of science such as «Our Nerves System» as any other unit found in biology; «The Sources of Electric Current», «What is Electric Current» and «Magnetism» as found among regular units of physics course.

Multi-purpose school idea died-off in a relatively short time. The results obtained from experimental Jr. H. Schools have not been publicly announced. Definitely it made no appreciable impact on the school science curriculum. The very same idea was brought into consideration at the Seventh National Education Convention where possibilities of establishing comprehensive senior high schools were discussed.⁶⁷ No such schools are realized as yet, despite the fact that the idea received a high degree of welcome in the Eight National Education Convention.⁶⁸

b. Istanbul Atatürk Girls' Lycée Experiment

Curriculum development activities at this lycée were carried out by a 35-member commission organized during 1954-1955 school year, and composed largely of the teachers of that school and a few educators. The studies have resulted construction of curricula which covered both junior and senior high school levels.⁶⁹ The science curriculum developed for the junior level integrates several scientific disciplines such as physics, chemistry, biology, geology, astronomy and hygiene.

The course, designed according to the curriculum developed under the title of «Natural and Physical Sciences» was taught four hours per week in all the three-years and included the following units: «The Solar System», «Living Things in Our Environment», «Natural Resources Above and Below the Soil» in the first year; «The Classification of Living Creatures», «Our Body», «Tools Which Facilitate Man's Work», «Energy»; in the second year; «Energy and the Conservation of Energy», «Travel by Land, Air, and Sea», «Sounds Around Us», «Light», «Materials Which We Use in Our Daily Life», and «Where Do We Use Electricity?» in the third year. The units are generally organized according to the principles of «the broad fields curriculum» and are similar to those found in general science of 1932; while in some ways they come closer to the structures of units found in independent disciplines of science. The curriculum developed includes general aims and specific objectives of the instructional units, however, they are not defined in measurable or behavioristic terms. No elective science courses were offered at the middle school level. The text-book prepared according to the curriculum was not supplemented by laboratory books or teachers' guide books.

On the other hand, the curriculum developed was assessed systematically by way of formative and summative evaluations. In the spring of 1955, the Testing and Research Bureau was assigned to evaluate the experimental program of the Atatürk Girls' Lycée. Because of inadequacy in the instruments of evaluation administered, difficulty was encountered in evaluating the results of the experiment. However, this difficulty was overcome by focusing on the first group participating in the experiment, the first class of middle school. By the summer of 1960, beginning with the 1954-55 school year, a battery of 21 tests, one value judgement questionnaire, one questionnaire dealing with student values concerning the program, problem inventory, and one survey on students' future study plans were developed and administered. The results of the measurements applied to these students were from time to time compared with the results obtained on other students. Furthermore, in order to determine the development occurred in this group as resulted from the experimental curricula the Beşiktaş Middle School was used as a control group in the 1957-58 school year. The comparison was made between matched pairs of the experimental and control groups.

Some evaluation results which particularly pertain to application in science education are given below:⁷⁰

1. In a comparison made during the 1955-56 school year, between the Atatürk Girls' Lycée experimental group and the Beşiktaş Middle School control group, tests are administered to matched pairs composed of 78 students. Differences of general ability of the students measured by the Otis Beta test favored the experimental group. Results of achievement tests on mathematics, geography, and science, as measured by the Primary School Graduates' Achievement Test, favored the control group significantly. The experimental group was unable to demonstrate superiority in the areas of learning measured.

2. In the 1957-58 school year, Thurston's Basic Abilities Test as well as Turkish, Natural Sciences, Social Sciences, Mathematics, and English achievement tests prepared by the Atatürk Girls' Lycée teachers were administered. Significant differences in favor of the experimental group were found. Although the results on the General Achievement Test of Middle School Graduates favored the control group, the differences were not significant.

3. The evaluation at the Lycée level was performed by administering the Otis Gamma General Ability Test and the Middle School Graduates Achievement Test, as well as the Educational Institutes General Achievement Test. The tests were administered to Atatürk Girls' Lycée students matched with Nişantaşı Girls' Lycée students. These tests were given to each group twice, in spring and fall, and the development averages obtained from each of the three tests favored the experimental group. However, the development measured by the Otis Gamma did not reach a statistically significant level.

4. An inventory of adolescent problems was administered to 60 students selected at random from both groups. In general, the number and importance of problems dealing with school, uncertainty concerning the future, and home and family life felt by the experimental group was less than that of the control group and the norm group. It is not possible, however, to make a connection between the results obtained and the curriculum applied to the experimental school, because there is a close relationship between

the problems and the socio-economic strata from which the students representing the experimental group had come.

5. The value judgements Questionnaire previously administered by Hyman and Payashoğlu⁷¹ and later developed by Allport, Lindzey and Vernon⁷² was administered at the end of the experiment to the Atatürk Girls' Lycée Experimental group and the Nişantaşı Girls' Lycée Control group. The results obtained showed in general that the school atmosphere of the experimental group had helped to develop «more Westernized ideas» in them, and that students in this group had more positive evaluations of «their teachers, school, and teaching methods» than the students in the control group.⁷⁰

c. The Ankara Bahçelievler Lycée Experiment

The Bahçelievler experiment began in 1955 and was run by teachers and administrators who had studied and gained experience in the United States for a period of one year; and was financed by the Ford Foundation. This was a part of a larger project to induce changes in Turkish secondary education under the leadership of foreign specialists.* Although the experiment began in 1955, covering the first years of both junior and senior high schools, studies concerning the freshmen year was later abandoned. The basic philosophy behind this experiment was similar to that of the Istanbul Atatürk Girls' Lycée experiment. For example, courses were organized as compulsory and elective; science and social sciences curricula were of integrated in character; the curriculum prepared included courses as special materials to meet the needs of able students to specialize in a discipline of study, e.g. science, mathematics or social studies; a balance was established between the ratio of weekly hours of compulsory and elective courses; a functional guidance was considered to be a fundamental part of curricular activities. However, the assessment made on validating the science curriculum developed at the Bahçelievler High School experiment was not as systematic and was not utilized as a fundamental part of curriculum development process as it was in the Atatürk Girls' Lycée experiment.

* Among them were Dr. Elsworth Tompkins, Dr. Lester Beals, Dr. Henry Mills, and later Dr. Thomas E. Benner, Dr. Will R. Burnett.

The unique characteristics of the Ankara Bahçelievler Lycée experiment concerning science curriculum, may be summarized as follows: ⁷³

1. At the junior level, an integrated general science is developed.
2. The subject-matter selected for the curriculum are arranged in the form of units of instruction.
3. Topics included in the instructional units are arranged around some central themes aimed at over-all development of the student and his adjustment to the existing social structure as was the case in general science curriculum utilized between 1932-1937 period.
4. The central ideas of units and arrangement of units in the instructional process are in line with the principles of adolescent psychology and psychology of learning. Units are arranged according to the proximity principle of teaching, and begins with the examination of man (the student himself) continues to understanding of his environment, from both social and physical view points, reaches the world from which it goes to universe and energy concept. The following headings of units taken from the science curriculum developed for the junior years illustrate this point very clearly:

In the first year of the Junior high school science curriculum the units of instructions are: Unit I: Research in Our Daily Life; Unit II: Our Body; Unit III: Growth and Nutrition; Unit IV: Behavior and Motion in Living Things; Unit V: Examining Our Environment; Unit VI: Investigations in Our Garden.

In the second year, the units are: Unit I: You and Your Future; Unit II: How Can We Lengthen Our Lives? (hygiene and combating microbes); Unit III: Edible Plants (photosynthesis; water-soil relationship); Unit IV: What We Have Gained from New Materials (the chemistry of substances used in daily life); Unit V: Modern Work and Means of Transportation (energy, and concepts of physics utilized in mechanical-chemical technology, transportation technology); Unit VI: Our House (the inclusion of this unit does not conform with the principle of proximity); Unit VII: The Earth and its Neighbors in Space (rotation of the earth, stars, planets, the solar system - basic astronomical concepts, and space technology).

In the middle school third year program, increasingly more units are devoted to concrete topics, but the units included neither support nor complete each other: Unit I: Studying the Earth's Sources of Energy; Unit II: Improving the Quality and Nutritional Value of Foods; Unit III: Electrical Energy and Its Use; Unit IV: Long Distance Means of Communication.

5. The interdisciplinary synthesis is neither topic-centered nor principles, laws and generalization-centered. In some units, relationships based on technology were established.

6. No text books, laboratory and teacher's guides, assessment devices have been prepared as curriculum materials of this experiment.

7. No clear indication based on careful and systematic assessment has been established as to judge the student's progress resulted from the experimental teaching of curriculum materials prepared as instructional units.

8. In the selection and arrangement of topics to be included into the instructional units prepared, considerable emphasis is laid upon the use of technology for social adjustment along with the development of scientific concepts and principles involved in these units.

9. Unit organizations of topics and related knowledges around central themes related to the application of technology for the solution of social problems are not in the form that will help to develop the student's critical thinking and problem solving abilities.

10. There is no clear indication that instructional process is organized around classroom strategies based on problem-solving method of teaching.

11. No special curriculum materials prepared to meet the individual differences that may exist in the instructional groups.

d. The Teaching of Physics by Film Experiment

Fundamentally this is an experiment concerning multi-media teaching in physics classes.

It took place at six lycées in Istanbul during the 1959-60 school year. The Ankara Girls' and Ankara Atatürk Lycées participated in it as control groups. The ultimate goal of the experiment was to determine the possibilities of increasing the effectiveness of lycée physics teaching in Turkey by making use of well-prepared products of educational technology (films, textbooks, teachers' guidebooks, students' guidebooks, teaching materials, a test package). The intermediate aims, in order of importance, were: (1) To inform teachers of new methods in physics teaching; (2) To assist in the inclusion of modern physics topics into the Turkish physics curriculum, and to provide Turkey with a translation of Dull, Metcalfe and Brooks' **Modern Physics**; (3) To translate into Turkish and provide Turkey with 162 physics teaching films⁷¹ developed by Harvey E. White; (4) To introduce teachers' objective evaluation techniques in physics teaching; (5) To initiate and develop the value of research in education and particularly in science teaching.⁷⁵

The study was financially supported by the Ford Foundation and the I.C.A.* It was in general planned by American experts and put into practice by Turkish technicians. The research design may be summarized as follows: Four experimental groups were selected from the ninth grades of four lycées in Istanbul. One group studied physics under the guidance of an experienced teacher using the Turkish versions of Harvey E. White films and the Turkish translation of Dull, Metcalfe and Brooks' **Modern Physics**⁷⁶, as well as the teachers' and students' guidebooks and adapted unit tests (Group A).

The second group (Group B) used all the same materials used by Group A but did not have an experienced physics teacher. The teachers of this group were selected among the teachers of mathematics or biology of the same school.

In the third group (Group C) physics was taught through correspondence; using a self-teaching curriculum materials. The course was handled by persons who had no teaching experience; and White's films were used.

(*) I.C.A. stands for «International Cooperation Agency» which handled American Aid to Turkey.

The fourth group (Group D) was taught physics by experienced physics teachers who used **Modern Physics**, as the textbook and who employed relatively conventional methods of teaching. White's films and the other materials were not used in this group. The teachers however were shown the White film dealing with the modern physics unit.

The results of the experiment may be summarized as follows:⁷³

1. No significant difference in achievement was found between Groups A and B. However when students were grouped according to their ability measures, it was seen that high ability students of Group A were more successful than the students of Group B with relatively lower ability.

2. Group D's achievement was higher than that of Group A. In short, on the learning materials tested the students of the group with experienced teachers which did not make use of White's films were found more successful than the students in Group A where teachers were experienced and the White's films were used in addition to the regular textbook. In that respect, it was not possible to judge whether the White films had a positive effect on the students' achievement in this experiment. This result may be due to the quality differences may exist between teachers of Groups A and D, and possible capacity differences may exist between the students in Groups A and D.

- 2a. There was a significant difference in achievement between the boy students in Group A and the girl students in Group B, in favor of the boys.

- 2b. The high ability students in Group A did significantly better than the low ability students in Group D.

3. The observed superiority of Group D over Group A was due to the difference of achievement found between the lower ability girl students of the two groups.

4. When Group A and the Ankara Ninth Grade Control Group were compared with Groups C and D as to their measure of achievement in the three-year physics syllabus, all three experimental groups were more successful than the control group. However, the group using a correspondence course (Group C) did not obtain a

statistically significant achievement difference. It must be kept in mind that as the control group was tested on materials which were divided over three years of education, it is natural to expect that an important part of the physics they learned in the ninth and tenth grades may have been already forgotten. In explaining the achievement difference observed in favor of the experimental group, one must take this fact into consideration.

5. When the experimental group (Group C) and the control group (eleventh grade) were compared according to sexes, it was seen that the Group C girls were significantly less successful than girls in the control group, while the Group C boys were clearly and significantly less successful than the control group boys.

6. It was observed that the end of the experiment, the teachers had gained considerable amount of new knowledge and principles related to physics.

7. According to the results of a questionnaire administered, students found the textbook useful, but found that the material was difficult to learn when condensed into a year's course; that the teaching tempo was too fast; that too much was expected of them; that the unit tests* were appropriate for their level; and that correspondence courses handled without regular teachers were difficult, even when supported with films.

8. The Harvey E. White films were found to be particularly useful for professional training of physics teachers.

The Impact of «the Alphabet Courses» Movement and the Science Lycée Experiment.

Sporadic experiments developed and conducted in the school science curricula by educators have merged with rapid spread of an international movement known as the alphabet courses movement originated in the U.S.A. Thus Turkey found herself in the midst of an intense international influence. This was the third time that Turkish school science was under the impact of foreign science.

* The achievement tests related to the teaching units were adapted by the author.

The first impact was felt, although indirectly, during the period of 1932-1937 which came from America and later on from Europe and resulted in direct translations of foreign origin textbooks into Turkish to be the main sources of school science curricula. The second impulse was received by the beginning of 1950's, which resulted in the development of sporadic curricular experiments in secondary schools in general, including curricular activities in school science. This was induced by American educators and supported by the Ford Foundation. The third impact has targeted directly the secondary school science education and the Ford Foundation was once again the initiator and the supporter of that. The impact came just at the time when for the first time school-university cooperation for curriculum development was about to begin* and had shadowed it, and has led to the establishment of Ankara Science Lycée in 1964.

A joint Turkish-American committee organized for that purpose agreed that «the most valuable asset of any country is its human resources and the most important element of human resources are highly gifted people» and that «a special Science Lycée would provide outstanding opportunity for the education of children with high aptitude in science; that a Science Lycée would prepare researchers for industry and for higher education in Turkey; and that a Science Lycée would improve science education throughout Turkey by serving as a laboratory for the development of curriculum materials which would be disseminated to other Lycées and would provide special facilities for training teachers for other Lycées». This way it was planned that the school to be established would «emphasize on modern curriculum materials and methods in science» and the students «would be outstandingly gifted in science» and the «teachers would be carefully selected and trained». ⁷⁸

After two years of planning and preparation carried jointly by some Turkish university basic scientists, a group of scientists and science educators from Florida State University and 30 teachers of science selected, the school began in the fall of 1964 with a selected

* A convention was organized for that purpose in Ankara by the participation of the Turkish Ministry of Education, teachers selected from secondary schools and social and basic scientists from Middle-East Technical University in 1962.

group of 100 students.^{78, 79} The physical science curriculum prepared as an introductory course for the freshmen year prepared by the Turkish scientists during the summer writing conferences held in Florida State University was subject to modification after its trial teaching in 1964 and has been condensed into a semester course because the trial textbook «had proved inappropriate both in spirit and in content as an introduction to the chemistry (CHEMS) and physics (PSSC) courses to follow in the second and third years. There was also a feeling that those later courses would need more time for thorough study». ⁷⁸ (p. 6)

It is seen from the above quotation that «the alphabet courses» movement had echoed in Turkey and resulted in importation of two alphabet courses namely **CHEMS Study Chemistry** and **PSSC Physics** as Turkish translations. For biology an adapted version of **BSCS Biology - From Molecules to Man** was developed. In mathematics a new course was developed by the Turkish mathematicians. In many ways the text prepared has a content organization comparable to **SMSG Mathematics**.

The general procedure of curriculum change and its implementation included as the beginning stage, textbook writing seminars held in Florida State University (1964); trial teaching of the course at Ankara Science Lycée in 1964-65 academic year as the second stage; revision of the preliminary versions of the textbooks written (summer 1965) based on the feed-back from their use with the first class, while some teachers of Science Lycée were trained in a summer work-shop and curriculum materials were prepared for the students who would enter the tenth grade in the fall of 1965 as the third stage; the above cycle was repeated as textbook writing, revision of curriculum material and in-service training of teachers in 1966 at the end of which writing of third year textbooks in chemistry, electronics began and completed; a Science Education Development Commission, under the chairmanship of the Head of the Turkish National Board of Education was established from among the university basic scientists who participated in the earlier stages of the Science Lycée Project, and provisions were obtained to make justifications on the Middle East Technical University's Entrance Examination systems for Science Lycée graduates entering universities; and also the support from the Ford Foundation continued as funds given to Scientific and Technical Research Council

of Turkey since project continued within the frame work of that council (1966-67) while summer workshops for in-service training continued—the fourth stage; the beginning of the pilot Lycée experiment as an extension of the science curricula of the first two years of Science Lycée into nine regular lycées as a three year science curricula on experimental basis by the beginning of 1967-68 school year as the fifth stage; comprehensive evaluation of the nine lycée experiment between 1969-71 as the sixth stage; continuation of experimental use of the alphabet courses in regular lycées and beginning of spreading of the new curricula into 100 lycées and 89 normal schools experimentally in 1971-72 school year as the seventh stage.

What are the striking changes that «the alphabet courses» movement has brought into Turkish Secondary School science curricula as appeared in way of translation, creation and adaptation with respect to objectives, assessment, content and process of the curriculum development? What did we learn from the Pilot Lycées Experiment and extension projects which are significant for science curriculum development? We examined the observed changes and innovations resulted from the movement as changes in time allocated to science, changes related to content and content organization, changes concerning process of instruction, objectives and evaluation as innovations in curriculum development.

a. Time Allocated to Science and Mathematics Teaching and the New Curricula.

Fundamentally the movement has resulted in strengthening the already existing trend of «more science» and modified it as «more and better science for all». The emphasis on science resulted from the impact of the movement is readily seen by the number of hours devoted to science and mathematics courses in the Science Lycée curriculum as compared to that of the regular high schools; and from the difference of the contents of science syllabi in the two types of high schools. As compared approximately to 1320 total number of hours devoted to science and mathematics courses in the three years education of the regular high school,¹³ a total of approximately 1720 class periods are devoted in Science Lycée.*

* In this calculation an average of 30 weeks of instruction time is figured out for a school year.

This is about one third increase in the total number of class periods in science teaching. This is a supporting evidence for the spread of the emphasis on «more science» as was created by the «alphabet courses» movement. However, it should be beared in mind that the observed increase in favor of science teaching in Science Lycée has not changed the ratio between weight of mathematics and science teaching over humanities that existed in the regular high schools; thus the increment was achieved by means of increasing total weekly teaching load from 32 hours to 40 hours. This way in the Science Lycée 600 class periods have been devoted to mathematics including geometry, 370 periods to **PSSC Physics** and 180 periods for either advanced physics or advanced chemistry or biology, 270 periods to **CHEMS Study Chemistry** and another 270 periods for modified version **BSCS Biology-From Molecules to Man**. Advanced courses are given according to the field of specialization of the students' choice. In this calculation fifty percent of total of 240 class periods given as elective is theoretically allocated for science oriented courses such as Modern Mathematics, Astronomy, Geology, Electronics of the senior year.

b. Changes Related to Content and Content Organization

As it has been already noted, despite the sporadic efforts of experimentation in high school curricula in the 1950's, until 1967 there was no nation-wide changes in science curriculum both in terms of its content and content organization. A typical syllabus of high school physics course in the old curricula, for instance, begins with the concept of measurements moves into force and vectors, leaving Newtonian mechanics for the senior year deals with heat, electricity and magnetism in the first year; then begins with geometrical optics and moves on to current electricity in the second year and finally Newtonian mechanics and physical optics are given in the last year. This content neither helps the student to develop an insight about the Newtonian universe, nor about the dual nature of light or the characteristics of the physical universe at micro or particle level. According to a systematic analysis of the content of high school physics syllabus that the writer made around 1960, it was evidential that the content did not include any modern concepts of physics such as thermodynamics, critical mass, chain reaction,

radio activity, mass-energy transformation, statistical mechanics, etc.. Therefore the translation of PSSC Physics utilized in Science Lycée as the textbook of physics course has not only made the content of physics syllabus up-to-date, but also helped the recognition of the historical development of physics as a science, the role of empiricism in this development, the nature of scientific investigations, and the boundaries and the problems of physics at present time. As noted earlier, however, the logical and chronological nature of content organization remained the same — although it was more systematically treated. Since the content of PSSC has been discussed in the earlier chapters we shall not mention it here again. Other forms of changes occurred in content and content organizations in high school science syllabus are examined below as curriculum innovations.

c. Curriculum Innovations

The «alphabet courses» movement has not only induced changes in the content and content organization of science syllabus by means of translations of PSSC Physics and CHEM STUDY Chemistry but also has led to the initiation of some creative work in curriculum construction and adaptation in high school science. Chronologically two innovative works, one in mathematics curriculum⁸⁰ by (Taner, et al, 1964) and another in physical sciences⁸¹ by (Baysal, et al, 1964) and an adaptation study in biology⁸² by (Karamanoğlu, et al, 1964) are the initial innovative products of the impact of the movement. Four years later two other innovative activities in school science appeared. One of them was the attempt of developing unified science curriculum for juniors high school⁸³ initiated by (Özinönü et al, 1969) and the other was elementary science curriculum development⁸⁴ by (Ölçün et al, 1969). They were planned according to the felt need to make the students at the lower level education to be more ready for the alphabet courses that they would take in their senior high school years. And the final work was again at junior high school level and was developed under the guidance of foreign experts in the form of instructional units by Oral and others⁸⁵ in 1974. Among these we shall examine briefly the works in physical science, adaptation of biology and instructional units developed for

junior high school by Oral and others. In the next unit the work of Özinönü's group is treated extensively as a case to illustrate aspects of development of a unified science curriculum.

BSCS Blue Version Biology was adapted into Turkish to be utilized as the text in a course taught in all three years of the Science Lycée. The first eleven chapters are included in the first year course with the addition of viruses, bacteria and paramecium as micro-organisms. In the adapted version malaria replaced formation of atolls as a sample problem of inquiry included in **Chapter I - Science as Inquiry** and extensive reorganization is made in the order of the content presented on photosynthesis and respiratory systems as the last chapter. It is a pity that adaptation has resulted changes which induced some undesirable pedagogical effects on the textbook. For instance questions given under «Self Check» in the original version which are fundamental for control of mastery learning, introductory passages given at the beginning of each unit and many of the «Highlights» given at the end of each unit which serve as significant means for continuity and quick review of the subject-matter and appreciation of historical development of biology as a science are omitted; and some contributive pictures mostly the pictures of eminent biologists which keep the students' interest in the text and in biology as a discipline of scientific work were not included into the Turkish version. Finally questions given in the chapter summaries are so modified that their contribution to the development of problem solving habits in students are minimized. Thus adaptation resulted in maximizing the deductive aspects of the content and reducing the inductive nature of the course. However, it should be noted that Turkish version of BSCS Biology has contributed greatly to expand the existing boundaries of teaching of biology as a discipline of study; to make the content up-to-date; to correlate chemistry with biology in a high school syllabus. Laboratory work as judged by the content and the organizations of the investigations given in **Laboratory Guides I and II** give the impression that experimental work are guided by cook-book type of prescriptions rather than by the use of inquiry steps.⁸⁶ Only in the laboratory works of the senior year, students are encouraged to involve investigations as individual or small group projects.

On the other hand, the text «**Introduction to Physics and Chemistry**» has been the product of a creative work of a group of

Turkish basic scientists with some consultation received from American men of science. Although the course for which the text had been prepared was first shortened from a full year course into one semester⁷⁸, and then was totally taken out of the science curricula of Science Lycée due to reasons not publicly announced and therefore unknown⁷⁹. It is worth to examine because of its unique character as a curriculum material.

It is already noted that the preliminary work was completed in 1964 summer writing conference and was put into trial teaching during 1964-65 school year. The text covers chapters dealing with «What is science?» as the introduction, «Measurement», «Matter and Mass», «Heat and Matter», «Elements of Matter», «Properties of Gases», «Electrical Properties of Matter», «Periodic System of Elements», «Structure of Matter - Atoms and Molecules» and «Chemical Bond». ⁸¹ The syllabus organization is such that after a comprehensive treatment of the process of science, concepts of physics gradually are merged into the concepts of chemistry around such central themes as matter and forms of energy, especially in units «Heat and Matter», «Electrical Properties of Matter» and «Structure of Matter». The content gradually moves from concrete observations to theoretical structures such as atoms and molecules as building stones of matter and inner changes of matter by building chemical bounds. It is not quite evidential however to claim that the content follows an organization in which parts of topics investigated are so tied together that the students while doing activities demanded by the units would go through steps of scientific inquiry as explained in «Chapter I - What is Science?». The text skillfully merges the laboratory activities with regular classroom teaching. However, no precaution or measures are taken to organize activities in accordance with individualizing the instruction. In units such as measurement where individual work would best fit for the mastery learning of such concepts as errors, systematic errors, averages, and measurement this principle has not been successfully utilized. Since no aims or objectives concerning the course are stated, there is no way of knowing what specific objectives the content organizers had in mind. As based on the interpretation of the structure of the content of the text, the content encourages the use of the principle of «learning by doing», however it is not clear whether «doing» involves «going through stages of

induction» or «going through steps of deduction» - because both types of activities are utilized in the presentation. Therefore by the structure and order of content organization it is difficult to claim that the writers had emphasized the development of scientific thinking and scientific attitudes in the student as the goal of this course. Since no evidence based on summative and formative evaluations are available to clarify the reactions of the students to the content, content organization, ways of teaching and objectives of the course and of the instructional units; and also the effectiveness of the content selected, the duration, intensity and velocity of the instructional process; the degree of change occurred in the students toward the targets selected for the course, as it is true for other curriculum materials prepared for the Science Lycée experiment, it is not possible to judge objectively the validity of the curriculum material developed. Likewise, it is not scientifically possible to justify the abundance of the use of this text from an introductory course at Science Lycée.

As the last innovative work in school science curriculum we shall briefly touch the instructional units prepared by Oral et al.⁸⁵ It should be noted at the beginning, however, that these instructional units have been prepared under the impact of the alphabet course movement thus are heavily based on E.S.S. (**Elementary Science Study**) and that the main themes as well as the content organizations of several of these units such as «Where Was the Moon», «Bulbs and Batteries» were presented in a seminar conducted by a group of international science curriculum specialists.* Let's have a closer look at these instructional units in order to reflect the basic principles of curriculum development behind them.

The content in these units have been developed, (1) around interest areas of the students of that age; (2) follow a structure which reflects both essential and distinctive characteristics of the «activity

* The group of foreign scientists composed of Dr. Gerald Abegg from IPS, Dr. Uri Haber Schaim from PSSC, Dr. Frank Watson from ESS, and Dr. Gleen Grumb from SCIS has conducted an in service and initiation seminar in Ankara Science Project Center, for Turkish teachers of science and scientists from Ankara University, Faculty of Science, Middle East Technical University and Hacettepe University between September 24 - October 13, 1973.

curriculum» where common interest of students such as the motion of the moon, sun, batteries and bulbs construct «common learnings» of the course; preparation of learning activities replace the strict advance planning as is found in well structured regular textbooks; content organization favors student-teacher cooperation in planning and conducting of the learning activities; no definite social direction is aimed at; and where problem-solving is emphasized. As stated in the introduction of these materials,⁸⁵ no systematic program of curriculum evaluation is foreseen other than soliciting the opinions of the users and others concerned, for validating the instructional units developed. Likewise, nothing is available as results of systematic evaluation of the trial and pre-trial teaching of the instructional units.

d. Appraisal of the Science Lycée Curriculum Movement

The Science Lycée Curriculum movement has involved tremendous amount of curriculum development activities in the form of textbook writing as achieved through Turkish-American collaboration by the participation of both Turkish and American university basic scientists and Turkish secondary science teachers. Despite its magnitude the process of curriculum development unfortunately suffered from the lack of systematic assessment which is considered to be the most significant constituent of such process.^{15, 17, 19} As a matter of fact, J. Stanley Marshall, the long time American director of the project, recognized the need for assessment as he says; «Several meetings in the early year (1966) failed to establish procedures under Project guidance for an extended program in testing and evaluation» and points out the possibility of overcoming such deficiency by stating in his critical evaluation of the whole project that:

«In retrospect it appears that the first step in the Project probably should have been the establishment of a long-term curriculum development center similar to those serving the Prefectures in Japan. Since the ultimate goal of the Science Lycée Project is the improvement of science education in Turkish Lycées generally, a short-range objective of such a curriculum development center might have been the development of curriculum for the Science Lycée and a long-range objective would have been to modify these materials for other Lycées. Experience in countries shows that large scale curriculum development

is a more demanding task than those associated with the Science Lycée Project saw it to be

In addition, and as noted above, a corps of Turkish professors should have undergone more serious study and training for long-term leadership in curriculum development and teacher education.

One or more Turkish universities — or perhaps a consortium comprising several universities and pedagogical institutes — should probably have participated in the Project beginning in its early stages.

..... the Project might have had a strong executive committee of Turkish scientists and educators ⁷⁸

Despite the indicated shortcomings of the project, some sporadic attempts concerning its evaluation were made. The first attempt appeared as early as 1966. However, it did not seek to validate the curriculum materials prepared by the Project, it sought to compare the reactions of Science Lycée second year students with those of a group of regular senior high school students on a battery of tests which purport to measure «power of learning» as an intellectual ability and possible behaviour differences between the two groups of students as measured by «IPAT - High School Personality Questionnaire». ⁸⁷ It was assumed that the difference to be observed between the two groups would reflect the difference of the process of science teaching and the science content existed between the two types of high school. ⁸⁷ The freshmen of Science Lycée as the experimental group was compared with the control group composed of 81 students selected from eight different Ankara senior high schools. The unique thing about the control group is that, they were selected from among the students who had applied to Science Lycée entrance examination in 1964 together with the students in the experimental group, and who had passed the first stage of the examination but had failed to be as successful as the students in the experimental group at the end of the second stage examination, and thus they were not admitted to Science Lycée. The same test battery on learning power was administered to both groups again a year later in 1966.

The «learning power» test includes items constructed on identical figures, comparisons of cubes, classification of figures mathematical ability, language ability, etc. which seek to measure general aptitude rather than mastery of the subject matter. As might

have been excepted, the experimental group was found superior over the control group in their abilities measured by the learning power test.⁸⁷ This finding was expected simply because, the students in the control group had been already found less able as compared to the experimental group students according to the measures obtained from a two stage competitive entrance examination composed of the similar tests that they all had taken when they had applied for the admission to Science Lycée.⁸⁷ Therefore this comparison was not very informative about the validation of the science curriculum of Science Lycée. What is interesting, however, this study established rather low correlations between various sub-tests of the Learning Power Test and the class grades that the students in the experimental group have earned in different courses of science and mathematics taught in Science Lycée. For example, the correlation coefficient between the sub-test called «Science-Achievement» and class grades of Basic Mathematics is only 0.19, between the same sub-test and class grades of the course titled «Introduction to Physics and Chemistry» it is only 0.16; and with Biology course grades it is only 0.13. Within a very odd distribution of the correlation coefficients found between various sub-tests and course grades, the maximum value found is 0.34 which is the correlation coefficient between the course grades average computed for all courses and the sub-test titled «Comprehension of Explanations and to Follow Directions.» The lowest correlation is between Biology course grades and «language ability» sub-test which is only 0.07 (Table 5, p. 16, Ref: 87).

Interesting enough again, that the comparisons based on the responses of the subjects both in the experimental and control groups on «IPAT Personality Questionnaire» show no appreciable difference between the profiles of the two groups as measured on such factors as «criticalness, anti-socialness, maturity, calmness, obedience, self-dependence or independence, conformity etc».⁸⁷ Thus, this first systematic attempt related to the evaluation of the Science High School curriculum development activities was such that it gave no comprehensive or consistent evidence to shed light on the validity of the curriculum developed.

In the second attempt made by Özinönü and Yıldırım the students attending in all three years of Science Lycée in 1966-67 academic year were used for purposes of comparison only. Primarily,

this evaluation study has aimed to investigate the role of the secondary school science instruction on the development of «scientific thinking ability» in the high school students and the influence of socio-economic conditions and teacher's qualifications on that development as well as on the student's achievement in school science and mathematics.⁸⁸

According to the study, the scientific thinking ability; (1) is a function of an appropriate science instruction, thus it develops with suitable ways of science teaching; (2) reaches a plateau and levels-off thereafter having developed continuously; (3) is measurable at any time segment during its growth. Thus, if the knowledge levels of the subjects are equated by means of appropriate test items, the measurement of scientific thinking ability becomes possible.

Scientific thinking ability is stipulated in the study in terms of behaviors which involve such cognitive operations as identifying problems, analyzing problems, stating problems in attackable or solvable forms; identifying among various possible solutions given for the problem the one which is supported by relatively higher number of evidences and which is most plausible; arriving at quantifiable conclusions by means of inferences made from hypotheses formulated and selected through observations, and experimental verification; arriving inductively at a generalization by means of invariable associations observed; making predictions about occurrences or events within the limits of error; applying generalizations and principles to explain phenomena scientifically; making use of analogies in explaining a new phenomenon; sensing, identifying and establishing cause and effect relations; arriving at scientific concepts by means of observation, perception, «thing idea» process; identifying basic assumptions underlying scientific theories and laws and principles; comprehending historical development of scientific disciplines and the problems and phenomena yet to be solved by science; judging and evaluating generalizations and arguments by means of pro and con evidences available; suspending judgement about seemingly convincing interpretations and plausible solutions till further evidences are collected.⁸⁹

A «Scientific Thinking Ability Test» constructed according to the above given stipulation and consisting of 120 items was administered.

nistered to 4190 seniors of 26 public senior high schools as a sample selected randomly from 148 public senior high schools according to stratified sampling technique. Thus, among 26 lycées included in the 18 % sample 8 was selected randomly from higher socio-economic regions, another 8 from middle socio-economic regions, and 10 from low socio-economic regions. Each sub-sample representing different socio-economic regions included schools of two different categories which is defined as the schools where science teachers with expected qualifications were in majority and the schools where the science teachers with expected qualifications were in minority.* The subjects took, along with the «Scientific Thinking Ability Tests», a «Science Achievement Test» composed of sub-tests in mathematics, physics, chemistry and biology constructed according to the existing high school syllabi, and a «Learning Power Test» aimed to measure the subjects' mental capacities.

According to the results based on the findings obtained from variance analysis of the data collected the following conclusions are reached:

1. Secondary school science teaching was found inadequate in either helping the student to develop the scientific thinking ability or to acquire the subject-matter covered in the science syllabi. Out of 40 expected average score of Scientific Thinking Ability Test, the average of the sample group is below 20; and likewise out of 65 highest expected score of the Science Achievement Test, some schools had an average around 28 while this average was 36 for students in the science sections of the high schools investigated.

2. Since national average on Learning Power Test as inferred from the sample is 37.5 and has been rather close to the expected highest score, the lower achievements observed on Science Achievement and Scientific Thinking Ability Tests may not be caused by the distorted distribution of the students' mental abilities in different regions of the country; it may be rather due to ineffective teaching of science in the secondary schools and to the existing inequalities of the educational milieu resulted from socio-economic differences of the school districts. The significant differences ob-

* Expected qualities of science teachers are determined by the criteria which are set by the Turkish Ministry of Education.

served among schools representing high, average and low socio-economic regions indicate that lower socio-economic conditions induce negative impact on the learning of the science subject-matter and development of the scientific thinking ability.

3. Science track students of the high school were found to be superior over the students enrolled the humanities track on both achievement and scientific thinking ability measured.

4. According to the comparison based on the averages, female students were superior than the male students both in subject-matter mastery and scientific thinking, despite the fact that no significant difference was observed between the two sexes in their averages obtained on the Learning Power Test.

5. No appreciable effect of the teacher's qualifications on the achievement and scientific thinking ability measures of the students are observed. This variable contributed positively in one type of grouping of the schools while it made negative impact on another type of grouping of the schools. Further investigation is needed in order to arrive at a sound conclusion.

6. Science Lycée students were found significantly superior than both national average and the highest national group measured by the Scientific Thinking Ability Test. Similarly, the average of the first year Science Lycée students is significantly lower than the average of the second year of the Science Lycée students while the difference observed between second and third year students of the same high school is not significant. This has been interpreted by the researchers as that : (a) scientific thinking ability is the function of an appropriate teaching of science and that (b) this ability develops more as the level of teaching increases but perhaps reaches a plateau after some learning.⁵⁸

It would be interesting to know which aspects of the scientific thinking behaviors stipulated are developed and are affected by various types of teaching (regular high school versus Science Lycée) and under different socio-economic conditions. The study gives a global score for the scientific thinking ability with no analysis of the scores related to different elements of this complex entity. Similarly, it would be informative if the results obtained by grouping schools according to the socio-economic levels of their

regions be further checked by grouping individual students in accordance with the socio-economic level of their family.

The first comprehensive study related to the appraisal of the Science Lycée movement began five years after the establishment of the lycée, and seven years after the initiation of the alphabet courses movement in Turkey. Therefore the study had not involved the appraisal of the curriculum development activities of Science Lycée, rather has aimed to evaluate first the Pilot Lycée Experiment then curriculum extension experiment in 189 academic high schools and normal schools.^{89, 90}

The first stage of the study which covers the Pilot Lycée Experiment aimed at investigating; (1) to what extent the new science curricula utilized in the Science Lycée experiment could be effectively taught under conditions of the conventional high schools, (2) how much of the new science and mathematics syllabi could be mastered by the students in the Pilot High Schools.⁸⁹ For that purposes two different measuring devices were used to collect necessary data. A questionnaire administered to the science teachers of the Pilot Lycées is supplemented by written reports of the supervisors, administrators and others concerned; an achievement and intelligence tests are administered to the subjects taking science courses in the Pilot Lycées and to the first and the second year students of Science Lycée in 1969-70 school year. A battery of achievement tests are prepared according to cognitive behaviors as formulated by Bloom et al. above knowledge level. Their reliability as computed by Kuder-Richardson formula ranges between 0.40-0.89 for physics sub-test, 0.57-0.67 for mathematics, 0.40-0.69 for geometry, 0.54-0.82 for chemistry and 0.51-0.78 for biology, and their validity based on the face validity as established by means of subject-matter coverage and by the assumption that Science Lycée group would show a considerable higher achievement on the test which they did. Despite the measures taken to motivate students toward the tests administered, this could not be achieved. However, according to Turgut, this did not reach to a magnitude to make the findings of the study based on test scores invalid.⁸⁹

According to the findings of the study the average achievement percentages varied between 20 % to 46 % in Basic Mathematics for the Pilot Lycée group while Science Lycée students obtained an

average percentage of 60 %. Except achievement in biology, the average achievements of the Pilot Lycée students decreased gradually from mathematics (35 %) to geometry (30 %), to physics (25%) and chemistry (25%). The group had the highest achievement in biology sub-test (40 %). In all sub-tests the Science Lycée group was found significantly and highly superior than the experimental groups and the average per cent success of the Science Lycée group is always around 50 % or higher.* More precisely, the mean of the raw scores obtained on 1110 Pilot Lycée first year students in the first semester on 33 items Basic Mathematics Test is 15.1, for the Science Lycée group 22.4; it is 11.8 in 34 items geometry test as compared to 21.7 as the mean of Science Lycée group again for the first semester; it is 10.9 for the experimental group and 24.2 Science Lycée in 42 items physics test; 13.2 and 29.2 in 42 items chemistry test; and 22.0 and 33.9 in 50 items Biology Test. Below is given a table to illustrate various averages obtained by experimental and the Science Lycée groups on different tests administered at the second semester.

Tests	No. of Items			Averages (Second Semester)					
				1st. Year		2nd. Year		3rd. Year	
	I	II	III	Pilot L.	Sc.L.	Pilot L.	Sc.L.	Pilot L.	Sc L.
Basic Math.	32	33	50	9.7	22.3	8.6	17.8	17.1	34.2
Geometry	30	30	37	7.6	17.2	7.3	20.6	14.5	18.3
Physics	38	35	45	9.7	19.6	9.2	13.9	12.2	14.7
Chemistry	40	38	35	8.8	24.6	9.5	19.5	9.6	14.0
Biology	50	50	50	20.7	37.4	18.9	23.0	—	—

It is readily seen that: (1) in every test Science Lycée group was found superior than the Pilot Lycées group; (2) the achievement of the Pilot Lycée group in the new syllabus is considerably low and is around first quartile in most cases; (3) highest achievement of

* Turgut computes the maximum and minimum per cent of average achievement by this formula:

$$\text{Achievement}_{\text{Max}} = \frac{100 \times \text{Average of Raw Scores}}{\text{No. of items in the test} - \text{Weighted Average of items belong to untreated topics.}}$$

the experimental group is in Biology; (4) excepting achievement in mathematics, there is a general increase in the average achievements of the experimental group from the first year to the third year, but the increase observed is not substantial to construct a trend in that direction since averages more or less are again around the first quartile; (5) a reverse trend is observed for the Science Lycée group where their average achievements on different tests tend to decrease as the level of education increases.

When Turgut computes averages corrected by eliminating chance responses, the average achievements of both experimental and the Science Lycée groups become appreciably smaller. For instance, while the average achievement for the experimental group on geometry test is 9.7 as computed from the raw scores, it becomes 5.3 when it is corrected by eliminating chance responses; likewise averages become 7.6 and 3.2 in geometry, 9.7 and 4.1 in physics, 8.8 and 2.6 in chemistry.

All these suggest that the learning of the students in the Pilot Lycées on the new subject-matter is not at an effective level, on the contrary the learning and cognitive behaviors that are to be developed by the «modern» science curriculum was minimal and is not adequate. Turgut sees that the observed deficiency on the learner may be caused by ineffective use of the instruction time, lack of readiness of teacher, inappropriate teaching strategy.

Although what suggested by Turgut as possible causes of the low achievement and thus inappropriate learning observed in the experimental group on the alphabet courses may be significant, it should be kept in mind that the input qualities of the two groups are not comparable since the Science Lycée group is selected with respect to their higher learning ability and possibly higher motivation toward science learning. Observations and some generalizations arrived at the study provide evidence which supports this view. For example, some schools in the experimental group was found having comparable achievement in several tests with that of Science Lycée group. When the observed considerably low achievement for Science Lycée group (e.g. 17.1 average obtained in 33 items mathematics test, 13.1 average obtained in 35 items physics test, 14.0 average obtained in 35 items chemistry test etc.) is regarded together with the under achievement observed in all the experi-

mental groups three fundamental issues come to mind as possible causes for the observed results. The first may be that the test items are constructed around cognitive behaviors which do not correspond to what the teachers of science aimed to achieve and thus are found to be higher than the expected behaviors of the classroom instruction, therefore tests do not meet the requirements of the criterion of «plausibility» which is explained in Chapter III. The second possibility is the lack of motivation in the subject toward testing which resulted as pseudo-achievement. Turgut also agrees on this possibility. And the third is related to the ineffective learning with respect to the duration, the intensity, and velocity, of the instructional process and the students' pace. This third possibility is a function of the teacher's qualification. Any or combination of these possibilities may serve as causes of the observed under achievement in both experimental and control groups. It is quite evident from the study that the Pilot Lycées Experiment provides findings which require a careful re-examination of the existing school science education policy and revision on the expansion policy of the alphabet courses to regular senior high schools.

The second stage of Turgut's study includes evaluation of 100 lycées and 89 normal schools with respect to the implementation of the new science curricula in these institutions. The study investigates the degree of effectiveness of the teaching of the syllabus of the alphabet courses composed of **PSSC Physics**, **Basic Mathematics**, and **IPS Introductory Physical Science** both at Humanities and Science tracks of the senior high schools based on the achievements of the students enrolled in various grades in 1972-1973 school year.

As far as the content coverage of the assigned instructional units given in these high schools and normal schools is concerned, it has been observed that in Mathematics I which is given in all ninth grades only 21 % of the total classes of 25 high schools investigated covered content assigned for teaching within 120 class periods allocated for the course during the first semester. The rest covered about 85 % of the topics assigned for teaching. In Mathematics II which is given in the second semester, out of 70 total classes investigated only 19 covered 81 % of the content assigned, yet another 19 covered only 40 % of the syllabus. In other classes content coverage was achieved between these limits. The same shortcomings with respect to content coverage was observed in all

other courses given. In **IPS**, for instance only 69 % of the syllabus was covered by 35 % of all the classes investigated. In **PSSC** the figures are 64 % and 46 % respectively. All these indicate that in the classes investigated classroom teaching was conducted only on certain units and leaving out 20-35 % of the topics included in the syllabus.

The achievements of the subjects investigated was measured by a battery of achievement tests prepared by Turgut by means of translation, adaptation of the English version achievement tests of the alphabet courses and also by innovative activities of the evaluation group. They included a 35 items test, Mathematics Test - I, a 40 items test, Mathematics Test - II for ninth grades; a 40 items test, Mathematics - III, a 35 items test, Mathematics - IV, two physical science tests, Test C1, C2, translated from IPS Tests and four physics tests adapted from PSSC Tests covering Optics I and II, Mechanics I and II.

The table below arranged according to the findings of the study illustrates that:

Tests	Items No. of	AVERAGES		
		Pilot Lycées	Other Lycées	Normal Schools
Math I	(35)	12.4	10.7	10.2
Math II	(40)	12.5	9.7	8.7
Math III	(40)	11.0	8.8	9.0
Math IV	*	9.1	4.5	—
IPS I	(32)	12.0	11.2	13.4
IPS II	*	10.4	7.7	8.7
OPT I	(56)	20.3	19.0	—
OPT II	(47)	12.4	11.9	—
Mech. I	(56)	16.9	14.8	—
Mech. II	*	12.9	10.1	—

* Adjusted averages.

* Turgut computes «adjusted averages» when some classes cover only some portion of the total syllabus thus are unable to answer items constructed out of that portion. For that he uses the formula,

$$X_{adj} = \frac{N_1P_1 + N_2P_2 + N_3P_3}{N_1 + N_2 + N_3}$$

where N stands for the number of students and P for the mean of raw scores.

1. Students' achievements in the alphabet courses syllabi are considerably low; lower than median and in many cases are around the quartile.

2. The students in Pilot Lycées were found superior than both those in the experimental lycées and in the normal schools. However, the study does not indicate whether the difference of achievement observed in favor of the Pilot Lycées is statistically significant. Similarly, the normal schools students had higher averages than those in experimental lycées in the areas measured by Math. III and IPS-1 and II and are found less successful in Math I and II tests. Again the study does not indicate if the differences observed are statistically significant.

3. Some students have omitted up to 55 % of the test items (e.g. Test Math II, experimental lycées and normal schools). This may be caused by lack of motivation toward the test.

4. In all students participated in the experiment the highest overall achievement was in IPS courses, second high in PSSC Optics, related to geometrical optics, and the lowest achievement was in PSSC mechanics. Thus according to the findings of the study as the units of instruction moves from optics to mechanics the students' achievement decreases appreciably.

5. No evidence is provided by the study about the nature of mastery learning in the units of the alphabet courses related to «modern physics». Therefore, to judge the role and the effectiveness of the impact of the alphabet courses in making the subject-matter up-to-date is not possible.

All these suggest that the alphabet courses movement has not yet made a nation - wide impact on teaching of high school science with respect to modernizing the content or the classroom strategy. Thus, although the movement has created a milieu favouring more science and better science for all, the widespread effectiveness of the impact in that direction is yet to be seen.

C. Science Curriculum for 1970's in Turkey

While the world efforts related to the secondary school science curriculum development are now focusing on a new central theme

as «man-environment-technology interaction» and a movement has been shaping-up in that direction, secondary science curriculum in the 1970's in Turkey is still trying to accommodate itself to the already modified policy known as «more and better science for all». As we have seen from the investigations given in the preceeding section, Turkey is not even at the middle of the road leading to that direction. Whether the pathway for curriculum development will be altered and modified by this new international influence or by the national demands that may emerge eventually is something to be seen.

V. A SAMPLE WORK - DEVELOPMENT OF A UNIFIED SCIENCE CURRICULUM FOR THE JUNIOR HIGH SCHOOL

In the preceeding chapters aspects of curriculum development on a theoretical basis and innovations and changes occurred in the secondary school science curricula have been investigated. In this chapter rather technical details of curriculum development process are examined by means of an experimental work conducted in relation to the development of a unified science curriculum for junior high schools. The presentation of the curriculum development activities includes, (A) Exploration of the need for a new curriculum; (B) analyses of the input characteristics of the curriculum users; (C) formulation of aim and behavioral objectives as the output qualities; (D) selection and organization of the subject-matter; (E) transformation of the subject-matter selected into instructional units and related educational technology by means of the principles of unification; (F) trial teaching of the instructional units developed; (G) assessing the instructional units developed and taught; and (H) general appraisal of the curriculum materials prepared.

A. The Need For a New Science Curriculum

As indicated in the preceeding chapter, the need for a new science curriculum for junior high schools has resulted from the impact of the alphabet courses movement. Since the movement

mainly had targeted at the second cycle of the secondary education, it was felt that, as happened everywhere else, the junior high school science curriculum should be revised and re-developed in order to prepare the students of the junior high school more efficiently to be ready to benefit from the new science and mathematics curricula that they would take during the senior years. Thus the need was super-imposed by the curriculum innovations in the upper level of the secondary education. This primary need was modified later by the project group as the input characteristics and the existing output-higher education relations for junior high schools were analyzed. It should be also noted that neither the Ministry of Education of Turkey nor the parents and students were satisfied with the existing science curriculum constructed around independent disciplines of study consisting of physics, chemistry and biology.

The need has led to the organization of a Science Curriculum Development Group* (SCDG) in 1967. The curriculum development project proposed by SCDG, approved and supported by the Ministry included the scope, plan, procedure, appraisal and implementation of the curriculum to be developed.⁸³ According to the proposal curriculum development activities can no longer be an enterprise that two or three people can undertake by way of speculation and reflective approach,⁹¹ it is rather a product of a systematic endeavour which involve planning, producing, trial teaching, assessing, re-teaching and thus developing a series of instructional units constructed around some central themes which are the backbone of the modern science. To achieve that end, an inter-disciplinary synthesis based on integrated disciplines of science including physics, chemistry, biology would be prepared. By the organization of the subject-matter selected the development of the scientific thinking ability in the students would be promoted and insured. Curriculum materials would be prepared as the instructional units constructed around central scientific themes which are suitable for interdisciplinary synthesis and the laboratory activities would be fused within the instructional units which later would be used as trial editions of a textbook. Also it was proposed that measuring tools and teacher's guide would accompany the instructional units prepared. The project proposal had foreseen the preparation of the experiment

* The list of the members of SCDG is given in Appendix - IV.

kits constructed by means of the locally available low cost and simple materials.

The plan of operation of SCDG included: (1) assessment of the characteristics of the input and the output of the educative process of the junior high school; (2) analyses of the existing science curriculum projects at junior high school level conducted all around the world; (3) preparation of instructional units by writing conferences in 1968 summer; (4) trial teaching of the instructional units prepared in three classes selected from Ankara junior high schools in 1968-1969 school year; (5) evaluation of the instructional units experimentally taught and other curriculum materials prepared — including unit tests, laboratory kits and teacher's guide — and writing of new instructional units in 1969 summer; (6) trial teaching of the already taught and revised units of instruction in all classes of the three Ankara junior high schools selected and trial teaching of newly developed science units in the three classes of the second year junior high schools in Ankara in 1969-70 school year; (7) ~~evaluation and revision of the units taught in the three junior high schools,~~ and preparation of new instructional units for the second graders of the junior high school, providing in-service training on the new curriculum materials prepared and tried to the science teachers of 30 junior high schools selected from all over Turkey and to the supervisors of the Ministry by a 4-6 weeks summer workshop and also preparing some units for the third year science course in 1970 summer; (8) experimental teaching of science units prepared, tried and modified for the first and second graders in 30 junior high schools selected, and trial teaching of the science units prepared for the third graders in three Ankara junior high schools in 1970-71 school year; (9) evaluation of the experimental teaching of first grade units conducted in 30 schools and the units taught in second grades of three Ankara junior high schools and also the units developed and tried on third grade classes in 1971 summer; (10) experimental teaching of all the instructional units prepared for first, second and third grades in 30 experimental schools in 1971-72 school year; (11) evaluation of the experimental teaching and final revision of the instructional units based on the findings of their evaluation; in-service training of the teacher's and Ministry's supervisors on the new curriculum materials prepared and training the Ministry's supervisors to be used as science curriculum consul-

tants for the implementation of the new curriculum for all junior high schools in Turkey.*

B. Analysis of the Input and Output Characteristics and Formulation of Broader Aims.

SCDG first examined the functions of the junior high schools in the Turkish school system. For that they have investigated the trends existing in the students flow from elementary education to junior high schools and from junior high schools to senior high schools of different kinds. As indicated in the table below, among approximately 50 % of the elementary graduates that enrolled in junior high schools a considerable number drop-out due to sickness, failure and other reasons.⁹²

Years	New Enrolment (Thousand)			Drop-Outs (Thousand)		Graduates (Thousand)
	Male	Female	Total	Sickness	Failure	
1961-62	91	28	119	1.1	20	44.6
1962-63	92	30	122	1	22	48

Source : State Statistical Institute.

Among those graduated from junior high schools approximately 34 % go to academic senior high schools, around 50-60 % go to technical-vocational senior high schools, 8-14 % go to normal schools and a small percentage terminate their education.⁹²

Considering the intense flow of the junior high school outputs into vocational education, besides the academic education and also the substantial drop-outs observed during the educative process at

* Despite the detailed program submitted by the project for curriculum development and its implementation, only some instructional units and other related curriculum materials were developed and tried because financial support provided by the Ministry was cut-off. Therefore the activities concerning the development of four instructional units are exposed here as a sample work for theoretical discussion of the aspects of curriculum development in an integrated science course.

this level, SCDG group realized that the curriculum to be prepared should not only serve those who would go to academic senior high schools and thus would take the alphabet courses in science in that level of education but should equally serve to those who would not be exposed to the alphabet courses in their later years of education and also to those who would terminate their education at their junior high school years. Thus junior high school in Turkey functions as an educational institution where general education must be given, where some students should be prepared for life and for living, some students should be prepared for higher level of education either in the academic or in vocational direction.⁹³ Therefore the curriculum to be prepared should include a common core suitable for all those heading to different directions in their future life and also provide opportunities fitting different needs of each group of students heading to a different directions. Thus SCDG formulated the following as the ultimate goals of education to be given at the junior high school:

1. Primarily, education at this level socializes the individual by giving him the «universals» of the culture. For that the school helps the student to develop behaviors necessary for effective citizenship, exploring his own potential and interests, and for effective thinking.

2. Education should provide opportunity for the individuals to overcome their background differences, and inequalities observed in their level of educational readiness resulted from existing socio-economic conditions and geographic differences.

3. Education should provide readiness not only for those whose destiny is higher level of education but also for those who would immediately begin to work for living.

In the light of these rather broader goals, the group formulated aims of the science curriculum to be developed as follows:

To help the student:

1. To gain knowledge about the physical universe around us, the role of science in understanding the physical universe and control of the physical phenomena for the benefit of mankind; the development of science as a discipline of study; the limits of science; the use of methods of science for solution of social problems; the technological problems existing in his country.

2. To develop scientific thinking by means of solving scientific problems through participation in activities which involve steps of scientific inquiry including observation, classification, data collection, hypothesis formulation, designing of experiment to test hypothesis formulated, logical and experimental verification of the hypotheses formulated, suspension of judgement about immature generalization, identification of assumptions included in scientific generalizations.

3. To explore, and identify his own values toward science and his potential for scientific activities, and to develop interest in science, and a positive value about the contributions of science on technological advancement and social development.

4. To acquire some practical skills needed for the use of the available tools developed by technology for better life, and for technical profession.

5. To develop group ways of thinking and behaving needed for a democratic life.

SCDG has been aware of the fact that some of these aims involve behavioral changes related to cognition (Aims 1 and 2), while others concern changes in affective behaviors (Aims 3-5), some of them are hazy, out of focus with respect to giving messages to the teacher about what he should do and how he should be certain whether or not they are achieved and whether or not they can be measured. For that SCDG has translated these aims into behavioral objectives included in the teacher's guides of the instructional units prepared and has given consideration to organize the subject-matter selected around problems which would guide students for the realization of such aims.

In their formulation of the broader aims SCDG comes closer to the conception of aims suggested by NSSE which include: (1) functional information about our environment and physical universe; (2) functional concepts and functional understanding of scientific principles; (3) functional skills needed for reading and understanding of science content, performing and designing simple manipulatory activities with locally available equipment, reading and interpretation of graphs, charts and other abstract means of expressions that are commonly utilized in science, making accurate

measurements; (4) problem-solving skills; (5) development of scientific attitudes, interests and appreciation.²¹

This way the aims formulated are considered as a significant part of the content selection activities and instructional process and have been formulated in consideration to the input characteristics and the expected output behaviors as suggested by Varış, Ertürk, and Bloom et al.^{7, 17, 22, 95}

C. Subject-matter Selected and Instructional Units Developed

The fundamental question that guided the selection of the subject-matter, according to SCDG was: «Is the subject-matter selected compatible with the objectives formulated?» Within that frame such criteria were utilized in selecting the subject-matter:

1. Is the subject-matter selected suitable for an organization which fits with the student's level of readiness and his ability of comprehension?
2. Is the subject-matter selected suitable for a content organization which promotes an integration among different disciplines of science?
3. Is the subject-matter selected appropriate for organizing learning experiences which ease and promote problem-solving ability of the student?
4. Is the subject-matter selected representative of the present level and comprehension of science?
5. Is the subject-matter selected reflective of the historical development of science?
6. Is the subject-matter selected representative of the process of science and thus suitable for development of the instructional process accordingly? Thus, is the subject-matter selected appropriate for experimental verification and testing?
7. Is the subject-matter selected appealing to the interest and curiosity of that age students and suitable for satisfying their basic needs?
8. Is the subject-matter selected translatable into measurable classroom behaviors to be developed by the student?

9. Does the subject-matter selected have some bearing to the exploration, identification, and solution of some social problems related to science and technology?

10. Does the subject-matter selected promote in the student values about the limitations that the present day science has in solving problems related to our physical (both organic and mechanistic) universe, and in providing explanations to various phenomena sensed and/or observed within our universe?

Under the guidance of the above leading questions SCDG first assessed the most profound and most comprehensive principles and concepts of science which are related with different scientific disciplines by means of investigation of the boundries and knowledge organizations of such disciplines as chemistry, physics, astronomy and biology. It was explored that change, thus motion, time, conservation, force, matter and energy are the most common and the most dominant concepts of all disciplines considered. It was also observed that the same phenomenon is investigated at least at macro and micro levels depending on the nature of the phenomenon and the discipline in which it is investigated. When the realm of astronomy is examined it is seen that fundamentally it included as the basic areas of study: (1) astronomy of observations; (2) practical astronomy; (3) mathematical astronomy or mechanics of the heavenly bodies, (4) astrophysics, and (5) cosmology. In all these areas basically the concepts included in Newtonian universe, in Euclidian space and wave-energy-matter relations are effectively utilized.⁹⁴ Many questions concerning heavenly bodies demanding answers at «what» and «how» levels can be effectively answered by the present knowledge of astronomy; however questions related to the beginning or origin and future of the man's universe are answered yet at hypothetical level.

Likewise, chemistry principally investigates matter and change and interaction between matter and matter, matter and energy. Basically this investigation begins at macro level and reaches explanations at micro level. Therefore all physical concepts related to matter at macro level, and matter-energy-matter interaction at micro (atomic and particle level) which are utilized in the investigation of physical phenomena are the concepts that chemistry as a discipline of science utilizes. It includes such concepts as mo-

tion, change, energy in various forms, configuration, affinity, reaction, reaction time, electron exchange, orbital changes of electrons, chemical bonds, electrical forces and nuclear forces. All these, to some extent, construct the initial step of changes observed in biological forms; since basically changes observed in biological forms are essentially chemical changes. Investigation of growth, reproduction of biological organisms involve investigations of change of matter at macro and micro levels.⁹⁴

Main concern of physics is the investigation of the pattern of interaction between matter and matter, and matter-energy at both macro and micro levels. Thus, by establishing some definite and/or probabilistic regularities or invariant associations to be found within this pattern of interaction in a well defined space-time system physics helps us to understand and to control the phenomena occurring in our physical universe. Therefore basic concepts of physics are related to change, motion within a given space-time model and nature and change of matter, energy, conservation, and causality, certainty, uncertainty established within that system.

Within the light of the aforementioned discussion concerning the boundaries of science and principal concepts of different scientific disciplines SCDG has tentatively drawn-up the following units as the subject-matter of the integrated science curriculum of the junior high school:

Unit I — Introduction to Science

- A. Knowledge as the Product of Science
- B. The Process of Science and Nature of the Scientific Investigations and Scientific Discoveries.
- C. Science and Mankind.
- D. Phenomena that Need Scientific Explanations.
- E. What You Will Investigate in This Science Course.
- F. Some Suggestions for the Student.
- G. Some Suggestions for the Teacher.
- H. The Use of Laboratory and Other Educational Technology.

- I. References and Related Reading Materials and Some Excerpts from them.
- J. Chapter Summary: Desk, Home and Lab Works and Questions.

Unit II — Change, Motion and Time

- A. Where is the Sun?
- B. How can we Trace the Apparent Motion of the Sun?
- C. Can we Duplicate the Apparent Motion of the Sun in the Laboratory?
- D. Moving Bodies and Time.
- E. Unit Highlights, Desk, Home, Laboratory Work; Questions and Student Projects.

Unit III — Change in Living Things and Time.

- A. How Tall Are We Getting Every Year?
- B. From Seed to Plant.
- C. Life Cycle of the Common Fly.
- D. Change in Living Things Takes Time.
- E. Unit Highlights; Desk, Home, Laboratory Work; Questions and Student Projects on Life Cycle of Most Hazardous Pests Found in Different Regions of Turkey.

Unit IV — Change in Matter and Time.

- A. How Fast the Odors Spread Around?
- B. How Fast Amonia Spreads Around?
- C. Time Needed for Gases Change Position.
- D. The Time Required to Make Lime Solution Cloudy.
- E. Experiments with Hypo Salt.

- F. Matter-to-Matter Reactions Require Time.
- G. Summary - Desk, Home, Laboratory Work.
Questions and Suggested Student Projects.

Unit V — Time and Change of Position.

- A. Space-Time Relations.
- B. Concept of Model.
- C. Unit of Time.
- D. Unit Summary - Desk, Home, Lab Work.
Questions and Suggested Student Projects.
- E. A General Review of Units II-V.

Unit VI — Matter As We See It.

- A. Can We Classify Matters Around Us According to
Some Distinctive or Common Characteristics?
- B. What Does Powdered Solids Tell Us?
- C. What We See By Microscope?
- D. What Happens to Solid Sugar Dissolved in
water?
- E. Experiments with Dye and Water.
- F. Unit Summary - Desk, Home, Lab Work.
Questions and Suggested Student Projects.

Unit VII — Building Stones of Matter.

- A. Molecules as Building Stones of Matter.
- B. Atoms and Atomic Particles.
- C. The Cell - Building Stones of Biological Forms.
- D. Unit Summary - Desk, Home, Lab Work.
Questions and Suggested Student Projects.

Unit VIII — How Building Stones Construct Matter.

- A. The Importance of Variety.
- B. The Importance of Order.
- C. The Significance of Chain Length.
- D. Man Made Matters. (Polymers - Synthetic Matters)
- E. What Else Science Must Explain About Matter?
- F. Unit Summary - Desk, Home, Lab Work.
Questions and Suggested Student Projects.

Unit IX — Change and Conservation of Matter and Energy.

- A. The Simplest Change in Matter (Changing of Observed Properties of Matter).
- B. How Do We Induce Change in Matter
 - Application of Force and Change in Matter.
 - Application of Heat and Change in Matter.
 - Electricity and Change in Matter.
 - Sound and Change in Matter.
 - Self Changing Matter - Radioactive Substances.
- C. Matter-Energy-Change and Conservation.
 - What Happened to Energy? - Is it Lost?
 - What Happened to Some Matter? - Is it Lost?
 - The Energy of Self Changing Matter.
- D. Matters in Our Daily Life.
- E. Unit Summary - Desk, Home, Lab Work.
Questions and Suggested Student Projects.

Unit X — Can We Change Matter Into Energy?

- A. Changing Heat into Motion.

- B. Changing Sound into Heat.
- C. Electricity Produces Motion.
- D. Burning Matter Produces Heat.
- E. Energy and Our Daily Life.
- F. Unit Summary - Desk, Home, Lab Work.
Questions and Suggested Student Projects.

Unit XI — Energy and Living Things.

- A. Light and Living Things.
(The process of photo synthesis - How Do We See?)
- B. Sound and Living Things.
- C. Heat and Living Things.
- D. Motion and Living Things.

Unit XII — Can We Change Energy into Matter?

- A. What Einstein Has Suggested?
- B. What Is Happening in the Sun?
- C. Atom and Hydrogen Bombs.
- D. Energy and Man's Future.
- E. Unit Summary - Desk, Home, Lab Work.
Questions and Suggested Student Projects.

Unit XIII — What Did We Learn From Science About Our Environment and the Universe?

- A. Science and Physical Universe.
- B. Science, Technology and Our Social Life.
- C. Development of Turkey and Science.
- D. Unit Summary - Desk, Home, Lab Work.
Questions and Suggested Student Projects.

The order of the unit organization of instruction given above increases in complexity, comprehensiveness and abstraction as the number assigned to units increases. SCDG had no clear decision about allocation of these different units to different grades of the junior high school other than that some of the units with smaller numbers would be instructed in the first grade while some of those with big numbers were thought of fitting to the instruction to be given in the third grade. The final decision concerning the allocation of instructional units to different grades would be reached after the trial teaching in the three classes chosen for experiment were accomplished.

The titles and sub-titles of the units of instructions suggest that the anticipated content of the text is quite different from the usual content of the texts of junior high school science which emphasize on health, medicine, transportation, communication as stated by Gervers,⁹⁶ Graham,⁹⁷ Hurd,⁹⁸ and Novak⁹⁹ in their systematic analyses of the contents of the junior high school science textbooks that are commonly used in the U.S.A.; and also different from the content of the General Science book utilized in the 1932-1937 period in Turkey as the adaptation of the textbook⁶² written by Pieper and Beauchamp in 1925, and also from the work of Burkman and his group, **Probing The Physical World**.¹⁰⁰

Excerpts taken from the instructional units developed on «Change, Motion and Time» may aid to illustrate how the content organization are related to the development of functional knowledge and problem-solving skills and how different scientific disciplines are fused around the central theme «change, motion and time». Since ample samples of the content of different instructional units are given in Appendix I, only a narrow section from it is taken here:

How do you realize when a day begins or ends?... Are there changes at home which tell us the beginning and ending of a day and night?..... When we observe the sun moving in the sky throughout the day, don't we see that it moves from the point it rises to the point it sets in the horizon? Can't we conclude from our continuous observations of the motion of the sun in the sky day to day that the sunrise is the beginning of the apparent (as it looks to us) motion of the sun while the sunset is the end of this apparent motion?.....

.....
How do we chase the apparent motion of the Sun?..... Fix a stick in a suitable place of the school ground and observe and measure the

lengths of the shadows of the stick at different times of a day, let's say morning, noon and late in the afternoon..... (Fill-in the table below according to the findings of your own observations.)*

Observation Time	Hours	Shadow's Length	Shadow's Position	Sun's Position
Sunrise				
Morning				
Noon				
Afternoon				
Sunset				

From Seed to Plant ... Put 5-6 lima beans between wet sheets, and cover them with a plastic bag. Observe (them) daily ... Write your observations in the table below.

Seeds	Days of Observations						
	1st	2nd	3th	4th	5th	6th	7th
Beans	No change						
Barley							
Wheat							
Lima Beans	No change						

It is readily seen from the above excerpts that the instructional units are organized around students' activities related to a physical phenomenon that they encounter in their daily life and they are curious to know about. A topic normally found in astronomy that is «the apparent motion of the sun» is integrated with a topic found in biology «germination» around a broader concept, «change and time» in these units. Content organization reflects an order of activities which involve observation, data collection, controlled experimentation, classification, interpretation, generalization and verification as commonly found in inquiry teaching.^{33,41} All these properties indicate that the unified science curriculum that SCDG has considered is not a sample of «the subject curriculum» which is widely used even in many of the modern textbooks based on the «alphabet courses», but rather represents a curriculum work in the «activity curriculum» concept.^{7, 41, 101} Thus the content is organized

* Parentheses are mine.

in the instructional units in such a way that it provides necessary experiences for the student to develop a sound «scientific literacy» which is foreseen as one of the most profound aims of unified science education¹⁰² by Showalter, Cox and et al. Similarly, the concepts of «change and time» around which four of the instructional units have been prepared are among the list of key concepts such as «cycle, energy-matter, equilibrium, symmetry, time-space, evolution, model etc.» which are suggested to be utilized as pivotal axes in the process of curriculum integration in sciences.¹⁰² In that sense, the units of instruction constructed by SCDG share the principles of content organization which are widely applied in **Science — A Process Approach** developed by AAAS.⁴¹

D. Other Curriculum Materials Developed

Other curriculum materials, besides the instructional units, that SCDG has prepared includes experiment kits, teachers' guide and a unit test concerning Units II-V.

Teachers' Guide exposes explicitly, the basics of the scientific knowledge covered in the instructional units concerned by providing a systematic investigation of the scientific syntheses, assumptions, principles and generalizations on which the content of the units are constructed. The guide explains the broader aims of the units, behavioral objectives based on these aims, the nature of the content organizations found in each unit, topical arrangement, students' projects to be encouraged, the necessity and the use of **Observation and Evaluation Notebook** that the teacher prepares concerning his own suggestions based on his experiences in teaching of the units; ways of assessment including the characteristics of the unit test; answers to the unit test and the questions found at the end of each unit; the use of related educational technology including the use of science laboratory and the role of extraclass activities; and constructive suggestions concerning classroom strategies to be employed in guiding the teaching-learning activities that the units involve. A rather detailed preparation of the **Teachers' Guide** is given in Appendix II.

According to the guide, the main aims of Units I-V related to «Change, Motion and Time» are to help the student; (1) to gain some

knowledge about change, motion and time in relation to the apparent motion of the Sun, the change and growth observed in germinating seeds, life cycle of house fly, and their own physical growth; (2) to develop an ability to use problem solving method in solving problems of science (e.g. Where is the Sun?, How fast the bean plant grows?, How taller are we getting each year?, Can we estimate the population of common house fly in different regions of Turkey? etc.) through observation, sensing a problem, identification of the real problem, formulating hypotheses as tentative solutions of the problems identified; developing working models, experiment or analogies to test and verify hypotheses formulated; arriving at generalizations inductively by the aid of facts established (3) to promote group way of thinking and behaving by way of class discussions concerning the data collected, their validity and reliability, the importance of averaging the findings obtained individually, validity and consistency of the conclusions arrived etc. around the problems investigated in the units concerned; (4) to develop a positive but also critical attitude toward science and its contributions toward the development of technology and social progress by investigating (for instance, pest control) by means of science; building of a shadow watch; are we healthy?, how to store safely and how to avoid hazards of undesirable germination of seeds, etc.

These aims are then translated into behavioral objectives in the guide. For instance, in «Unit I — Where is the Sun?» some of the behavioral objectives formulated are as follows:

At the knowledge level:

- The Sun rises in the East and sets in the West.
- The Sun is almost stationary, it is the rotation of the Earth that makes us see the Sun moving. Therefore the motion of the Sun in the sky is not a real motion but an apparent one.
- A moving body can not be in two places at the same time.

At the concept level :

- Concepts of time, position, orbit, source of light, rotation, apex, curve, model.

At the level of analysis and synthesis :

- If at any given moment, a body (the Sun) is at one place, if another moment it is at another place then this body is in motion.

Again according to the guide, in establishing the close relationship existing among change, motion and time science utilizes a series of assumptions that the teacher should be keenly aware of. Among them are, «For a change to occur, a medium is necessary,» or «The notion of a physical medium necessitates the notion of a physical universe». There are some logical and consistent relations among concepts that constitute the physical universe, such as «If an observed physical object does not change its position with reference to a given point, it means that the time position does not change» etc.

As to the teaching strategy to be emphasized in the teaching-learning process involving the units concerned, the guide states: «In treating a unit ... (students must be guided to face)* with a problem situation, then they will observe the event in actuality «observation», will collect data «phenomenological data» on which an informal class discussion may be developed, then the event will be reconstructed, thus duplicated in the classroom or in the lab by the student individually or by small groups composed of two or three students under the experimental and controlled conditions «design of experiment» another set of data will be collected by which some conclusions, tentative generalizations and mathematical relations are inductively arrived. The relationships established and the generalizations arrived in these units may not be as cause and effect relations. They may be rather temporal and spatial relations at descriptive level. The relations established ordinarily are not to be stated as mathematical formulae, but rather, whenever possible, will be expressed in graphical forms». The guide suggests alterations to be made by the teacher, whenever necessary, to re-arrange the experiments designed according to the prevailing conditions of school regions. Since several learning activities may require observations made out of class (e.g. germination of seeds, solar time, life cycle of the fly, etc.) it may extend the student's school day. Therefore, care should be taken for effective planning, presentation and

* Parantheses are mine.

evaluation of such individual or small group works in the class. Thus suggested time allocated for each unit may be altered accordingly, states the guide.

For evaluation, the guide suggests a careful assessment to be made of the student's individual or group work achieved through different in and out of class activities and checking their level of achievement by small quizzes to be given at the end of each unit and summative evaluation based on the students' performance of the unit test to be administered at the end of the fifth unit.

It is also suggested in the guide that the teacher is free to make changes in the order of the instructional units to be treated, as he deems necessary because of the unique characteristics that may exist in his class group. The guide includes useful sources of references both on aspects of the child development, teaching process, evaluation techniques and the subject - matter investigated. In this respect the guide possesses properties of a «resource unit».^{108,104} No remedial teaching, other than the individual student projects, is suggested in the guide; and no special curriculum materials²⁷ was prepared to meet the individual differences that may exist in the input.

E. Trial Teaching and Evaluation of the Curriculum Materials Prepared

Instructional Units II-V related to change, motion and time was experimentally taught to a group of volunteers between June 27 — July 4, 1969 at a primary school in Ankara. The group was composed of 32 elementary school graduates, 16 females and 16 males who could participate in the experimental teaching only between June 27-29, 1969 after which some of them had to leave the city for pre-planned summer vacation. Thus, those who participated in the teaching activities thoroughly is about 20. The average age of the experimental group is 11 years, and the group was about 8 months younger than the group for which the curriculum materials were prepared.

According to the log written during the experimental teaching in all teaching-learning activities conducted the students were very

much motivated in learning and participating in class work, the teaching strategies suggested in the Teachers' Guide was found appropriate, the subjects enjoyed the curriculum materials prepared. The total interaction time on the materials and activities covered in instructional Units II-V is 24 hours. Trial teaching has revealed that Unit III which investigates «How Tall Are We Getting Every Year?» and «From Seeds to Plant» were found more appealing and relatively easier for the students and thus they should be investigated before «Unit II -- Where is the Sun?»; and that more time should be allotted to Units II and V; some special curriculum materials probably in the form of self teaching should be developed for slow learners and science shy students¹⁰⁵ especially in the topics dealing with graphical representation and interpretation of graphs; the time, the organization of the instructional processes suggested for Units III and V were found appropriate in reaching the objectives formulated for the units concerned. The majority of the group has developed basic concepts and principles treated in all units; and that for a sounder evaluation of the units experimental teaching with different inputs (both socio-economically and in terms of their innate capacities) and in a regular class setting with 40-60 students may be needed. It was also found that the Teachers' Guide developed was very comprehensive and well organized to provide guidance to the teacher in the subject-matter covered in selecting appropriate teaching strategy, performing the necessary experiments and guiding the student activities effectively.

The effectiveness and suitability of the curriculum materials prepared for the teaching-learning process to be conducted with this age group was also checked, besides the teacher's observations and interviewing of the students participated in the experimental teaching, by means of an objective test administered to the group at the termination of the experimental teaching. For that purpose, a forty-eight items, multiple choice with four distractors achievement test was prepared covering the subject-matter of the units concerned and oriented toward measuring the degree of the realization of the objectives formulated. Thus the test included items aimed to measure the development of the behaviours of the subjects related to knowledge, translation from concrete to abstract or vice-versa, extrapolation, application of principles into novel situations, analysis of elements and principles which are included in the units

of instruction experimentally taught. Some representative items of the test are given in Appendix-III.

The average achievement of the experimental group based on the raw scores is 32.40, while one individual received raw score as high as 46 and two students got 42. The range is 23 and the lowest score is 23. When the same test was administered to a small group of Middle East Technical University seniors majoring in science, although their average was a bit higher (33.28) than the experimental group; but when the upper limits of the distributions of the two groups were compared, the achievement of the experimental group was found higher.

All these provided evidences that : (1) the curriculum materials developed by SCDG were at the student's level of comprehension; (2) the subjects enjoyed the materials prepared and the learning activities developed in the instructional units; (3) some re-arrangement in the order of presentation of the instructional units may be needed; (4) some special materials should be prepared, and some revisions should be made especially in Unit I in order to help the science shy students^{105, 106} more effectively in skills needed for graphical representation or constructing graphs by means of data collected; (5) both Teachers' Guide and the achievement tests prepared for the instructional units are found effective. However, supplementary evidences obtained on evaluation based on experimental teaching with larger and varied class groups may be needed to generalize the validity and effectiveness of the curriculum materials prepared.

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APPENDICES

Appendix I

**EXCERPTS FROM INSTRUCTIONAL
UNITS II-V «CHANCE, MOTION AND TIME»**

SAMPLES FROM TEACHING UNITS ON CHANGE,
MOTION AND TIME.

Unit I. WHERE IS THE SUN?

A. **Time and the Apparent Motion of the Sun** — How do you realize when a day begins or ends? How can we determine the beginning of a day? Are there changes at home which tell us the beginning and ending of a day and night? What changes take place when a day begins? Isn't it the sunrise in a cloudless sky that let's us know that a day has begun? As dawn is the beginning of a change, so is dusk. With the sunrise, a day begins, with the sunset a night begins. For us, the earthly creatures, it is the sunset or the sunrise that sets the beginning of a day or a night. Have you ever thought what sunrise or sunset really mean? When we observe the sun moving in the sky throughout the day don't we see that it moves from the point it rises to the point it sets in the horizon? Can't we conclude from our continuous observations of the motion of the sun in the sky day to day that the sunrise is the beginning of the apparent (as it looks to us) motion of the sun while the sunset is the end of this apparent motion? Therefore, don't we determine the length of a day, that is how long or how short a day is, by checking how the points of the sunrise and the sunset change from one day to another. If so, change, and motion as a special conception of a change, make us perceive the time. We therefore can conclude that time and motion are twins. In a way they are identical twins. Saying it more scientifically, every change requires time.

B. How Do We Chase the Apparent Motion of the Sun?

We have already discussed the relation between time and motion. Let us now try to explore this relation experimentally by investigating the apparent motion of the sun more systematically.

Experiment I. Experiment with Shadows of the Sun.

Fix a stick in a suitable place of the school garden and observe and measure the lengths of the shadows of the stick at different times of a day, let's say morning, noon and late in the afternoon. In order to be systematic, let's measure the length of the shadow, and observe positions (whether extending to the south-east or to south-west) at fixed clock times e.g. at 9 a.m., 12 noon, and 3 p.m. What do you need to carry out this simple experiment? If your friends are also doing the same experiment should the lengths of the sticks that each of you use be identical for purposes of comparing your results? Should the sticks be located identically for the same reason? Do you need a clock, a meter stick and a compass for measuring the lengths of the shadows and determining their positions? Are you ready to do this simple experiment? Or do you need to know the local north, east and west directions? How can you determine them? Once you determine these geographical directions are you ready to go ahead and complete your experiment with sun shadows of the stick? If so, each of you should be capable of filling out the necessary data in the table given below:

TABLE I — Observations of the Length and Position of Shadows of a Fixed Stick and Location of the Sun During Observation.

Time	Hour	Length of the Shadow	Position of the Shadow	Location of the Sun
Sunrise				
Morning				
Noon				
Afternoon				
Sunset				

Discuss and compare the data (the recorded observation results) with your friends and answer the following questions:

1. When is the length of the shadow shortest?
2. What is the relationship between the shadow lengths at the moment of sunrise and sunset and the shadow lengths observed at different times of a day?
3. What are the relative positions of the shadow observed at different times of a day?
4. How do you think the relative positions of the shadows observed at different times of a day will change with the change of seasons? Will the shadows' position be the same when the observation is made say at the same time of the same day (e.g. 9. a.m., Thursdays) regardless of the time of the year when the observation is made?
5. How about the length of the shadow, will it change with the change of the seasons?

If you make observations year around, you will have sufficient data accumulated in your table to enable you to answer all of the above questions with confidence. How about reversing the process? Instead of making observations and collecting data and interpreting the results obtained, what would happen if you were given a table similar to the one you filled out with your own observation results but having the last column blank (that is location of the sun blank). Can you predict the location of the sun correctly? If so, fill out the missing parts of the table given below.

TABLE II — Data Based on the Observation of the Shadows of a Tree in Ankara on March 21st.

Observation Time	Length of Shadow (m)	Position of Shadow	Location of the Sun
	7.8		
	2.4		
Noon	1.2	North	
	3.2		
	6.8		
	16	East	

SAMPLE II — FROM UNIT ON CHANGE, MOTION AND TIME.

2. TIME AND CHANGE IN LIVING THINGS

A. How Taller Are We Getting Every Year?

How can we know how much taller we are getting every year? If we had our height measured each year beginning with one year of age up to the present time, wouldn't it give us a good measure of how much taller we get, and a reasonable measure of our **growth rate** in height? Two graphs, one indicating the **growth curve** of boys, and the other of girls, are given below. Examine each graph carefully and compare your own growth rate with that of the graph.

The data used on these two graphs represent people of average height. There are different graphs representing people belonging to the group with shorter than average height and to the group with taller than average height.

Data representing relatively shorter and taller people's growth rates are given below in two tables, one for boys and the other for girls.

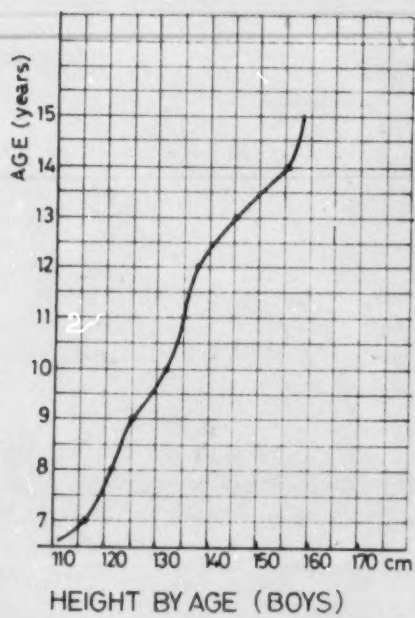
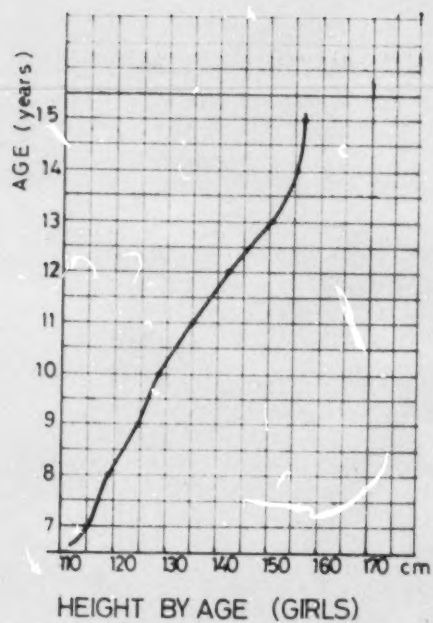
TABLE III — Changes in Height of Boys by Age. (For Short and Tall Groups)

AGE	HEIGHT (cm)	
	Short Group	Tall Group
6	102,5	119,5
7	108	126
8	112	130
9	116,5	135,5
10	121	141
11	124,5	145,5
12	128,5	149,5
13	134,5	155,5
14	141	165
15	146	170

TABLE IV — Changes in Height of Girls by Age. (For Short and Tall Groups)

AGE	HEIGHT (cm)	
	Short Group	Tall Group
6	102	118
7	107	125
8	110	128
9	115,5	134,5
10	119,5	138,5
11	124,5	145,5
12	133	155
13	138	162
14	142	166
15	144	168

Appendix 1-6



By the aid of the data given in Tables III and IV you can draw four different graphs like graphs given previously for the boys' and girls' groups with average heights. Here again, as you have done earlier, mark the ages on the vertical or Y axis, and the heights corresponding to the ages on the horizontal or X axis. Then draw a horizontal line from each age parallel to the X axis, likewise a vertical line from each height parallel to the Y axis and mark wherever each pair of lines intersect. When you join the points of intersection one after another, you obtain a graph or a curve which represents the relation between the heights and ages of boys and girls.

SOME QUESTIONS FOR YOU

1. You know your age. Have a friend measure your height and find out which growth group (short, average, tall growth groups) you belong to.
2. Considering the boys only, what is the age of the fastest growing boys in each group? Is this age common for all three growth groups?
3. Between the ages 6-8 do the boys or the girls grow faster? Are the growth rates of boys and girls of this age group identical?
4. In what respects is the growth of girls belonging to all three growth groups different from the boys in the three growth groups? (Consider and compare average heights, growth rates, faster growth periods, etc.)
5. Consider a boy falling into the average growth group and having a height of 139 cm, how old do you think this boy is? What assumptions must you make in order to identify the boy's age with certainty?

FOR ALL YOUR ANSWERS MAKE USE OF THE INFORMATION GIVEN IN TABLES III AND IV and GRAPHS 2 and 3.

The rest of the unit covers the following activities: How can we find the Average Height for All the Students in Our Class?

Home, Class and Lab. Work.

Some Questions.

A Sample Text From «Time and Change in Living Things».

2. TIME AND CHANGE IN LIVING THINGS

B. From Seed to Plant

a. **Germination** — Take two containers, a glass and deep plate. Put a couple of sheets of blotting paper in the plate. Put 5 or 6 lima beans between sheets, and cover them with a plastic bag. In the empty glass put five or six seeds of four different varieties, e.g. beans, barley, wheat and corn and fill it with tap water. Close the top of the glass airtight by means of a plastic wrapping and a rubber band. Put these two containers side by side in your room near a window. Observe the seeds in both containers daily and wet the absorbent papers in the plate whenever needed so that they are always kept wet. Write your observations in the table below.

TABLE VIII. OBSERVATIONS ON SEEDS

Seeds	Days of Observation						
	1st	2nd	3rd	4th	5th	6th	7th
Beans	No change						
Barley							
Wheat							
Lima Beans	No change						

What happened to the beans in the plate? Did you observe any change in them? When? How did they change? What happened to the seeds in the glass container? Have you observed changes in these seeds similar to those you observed in the beans in the plate? Can you conclude that there has been no change in the seeds in the glass container? Open the plastic wrapping and smell them. Do you feel any change? Take a few seeds out of the container and examine them closely. Are they as healthy as they were originally? Or did they get rotten and decayed? Did they germinate?

Now compare your observation with the **generalizations** given below. See if your observations are in agreement with the generalizations, or contrary to the generalizations.

1. When the medium (or conditions such as humidity, availability of air, temperature) changes, seeds go through a change. When the conditions are suitable, the seeds germinate.
2. When they are put in appropriate conditions, (as in the case of the seeds in the container) the seeds get rotten.
3. Germination requires both time and appropriate conditions. In other words, germination is a time-consuming process. By knowing the amount of time which has passed in the germination process we can determine the stage of germination. (Is this true for every case?)
4. The generalizations arrived at above can be summarized as follows:

Seed + Suitable Conditions + Time = Germination (Change)

Seed + Unsuitable Conditions + Time = Decaying (Change)

As you observed, in both cases change required time.

b. **Growing** — Now put the germinated beans in a glass or clean plastic container and cover them with soil. Place the container in a place of your room or class room where it will receive some sunlight. Water the germinated seeds in the soil once a day. Make daily observations of change and note the day and the time when

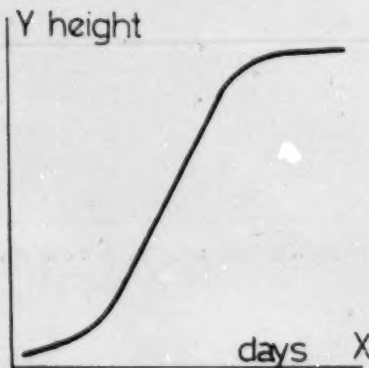
you observe that a green plant comes out of soil. With a series of observations, let's say once every day (24 hours) fill out the table below with your data (collected information) indicating the length of the plant above the soil surface. In order to be more **accurate** in your measurements use the same ruler and place a piece of cardboard on soil surface on which you place your ruler.

Growth of a Plant

	Days						
	1st	2nd	3rd	4th	5th	6th	7th
Length of the plant (mm)							
Daily increase in length of the plant (mm)							

By means of the data you collected on the growth of the bean plant draw a graph. Make use of what you have already learned about drawing graphs. Now compare your graph with the graphs given in (Figure 6) and (Figure 7).

c. **Further Help For Those Who Have Difficulty in Drawing the Graph** — You know the lengths of the plant each day you



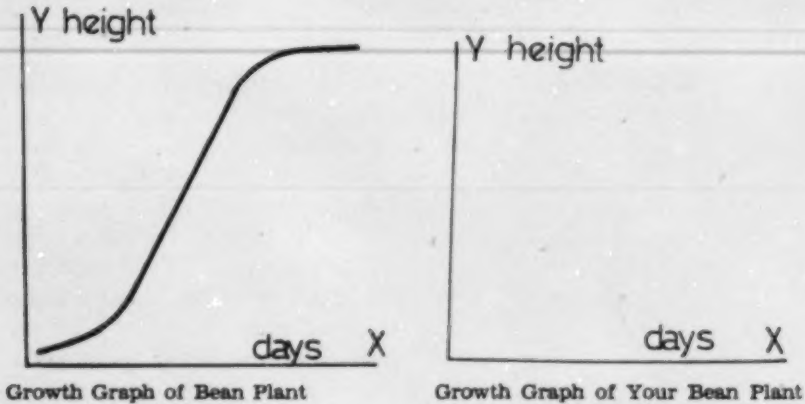
Growth Curve of a Plant
Figure 6

observed and measured it. You also know the **rate of growth** of the plant. Or don't you know it? O.K. Take the height of the plant on any day and subtract the height of the plant on the previous day and you'll find out **how much the plant grew in that particular day**. This is called the **daily amount of growth** or **growth rate** of the plant. If the plant grows the same amount each day then it is a plant with a **constant**

growth rate. The graph is an economic and a precise way of telling all this to us.

You remember that we had drawn a graph representing the shadow of a pencil (P.). You are going to follow the same steps as you did previously. **Since growing requires time** we shall indicate time on one axis. Let's plot the time on the X axis, and the length of the plant on the Y axis. Then by drawing parallel lines from your values on the X axis to the Y axis, and from your values on the Y axis to the X axis you will find where they intersect. Mark the points of intersection. When you join these points of intersection in a smooth manner you obtain the **graph representing the growth of the bean you observed.** Draw your graph on the coordinate system (X axis and Y axis system) which is given below and compare your graph with that we drew by means of experimental data we obtained at the Science Lycée, ANKARA.

Science Lycée, Ankara



To what extent your graph is similar or different from the graph based on the experiment carried at Science Lycée, ANKARA? If you find differences between the two graphs can you think of

some reasons which may explain the differences? If you take the same distances for days and for lengths as we did in our graph and draw yours on a transparent paper you can put your graph on ours and you can compare them much more easily.

d. SOME QUESTIONS FOR YOU:

1. If we name the graph showing the daily rate of growth of a plant, «graph of velocity of growth» in what ways this velocity graph is different from the growth graph?
2. Draw the velocity graph (it is also called velocity curve) of your plant and determine the days when the growth is the fastest and the slowest. Is the rate of growth of the plant uniform? Or does it change day by day?
3. With respect to growing process of the plant can we generalize that «when conditions are suitable both the trunk and the roots of the plant grow simultaneously?»
4. When such conditions as sun light, humidity fertilizer etc. are kept identical, will the growths of different plants be also identical? For your answer on this question consult the observations that your friends made on different plants. Make a table showing the order of growth rates of different plants.
5. In the light of the data that you and your class mates collected on different plants criticize the following generalization : «when conditions are identical velocities of growth of different plants are also identical».
6. In order to understand the relations between sun light and the growth of a plant imagine two plants (plant A, and plant B) from identical seeds at the same length. Assume that Plant A is kept under sun light all day long for ten

days and Plant B is kept under sun light all day long for ten days period. Predict what differences you would observe between the growth of the two plants. Write your predictions below. Then make your experiment and write your observation results. Check how reliable your predictions were:

YOUR PREDICTIONS :

OBSERVATIONS :

DISCUSSION :

Appendix II

**EXCERPTS FROM THE TEACHERS'
GUIDE ON TEACHING UNITS II-V**

Excerpts From the Teachers' Guide

Some illustrative samples are given below taken from the Teachers' Guide prepared on Instructional Units II-IV. «Change, Motion and Time».

Scientific Explanation

The aim of these units is to present a rather close relationship existing among change, motion and time through a series of such activities as experience, experiment, mathematical expression, conclusion and generalization that the students will perform. In establishing these relationships, the following assumptions should be considered:

1. In order for change to occur, a medium is necessary; this medium is the physical medium. The notion of a physical medium necessitates the notion of a physical universe.
2. If a definite point in the physical universe is taken as a reference point, the concept of time is derived from the change in position of other physical objects when compared with this point.
3. When the concept of time is thus presented, we may think of amounts of change in position as time intervals.
4. It is necessary to explain that one must think of the time difference of a physical object in a particular position, along with that position. Thus, the time vector joins the position vectors.
5. It is not possible to speak of change without a physical medium. It is not possible to speak of time without change. It is meaningless to speak of time in a medium other than a physical medium; or in a physical medium in which change does not take place.
6. If an observed physical object does not change its position with reference to a given point, it means that the time position does not change either. If however we take as our point of reference, a

point in another reference system, and we observe the relative position of the observed object to the positions of the objects in the other system, the first observed object, which appeared to be motionless, will now be observed as changing in time and position when compared with the changing positions of the other objects. Thus, the time vector of the first observed object will be seen as not being constant.

7. Thus position is expressed by the addition of a fourth dimension, the time vector, to the three-dimensional Cartesian system. We do not expect the student to learn the above theoretical explanation directly. The generalizations, concepts, and other cognitive behavior expected from students are given below.

The Scope of the Unit

In this unit room has been given to various experiments and activities taken from astronomy, physics, chemistry, and biology, all for the purpose of approaching the above-mentioned theoretical relationships. These topics are the motion of the Sun, the sun's shadow, the rotation of the Earth around its axis, the diffusion of gases, reaction time, change and time in plants and living creatures (the germination of seeds and growth, the life cycle of the common fly, the change in our height and weight over a period of time, relative motion, and measurement of time.)

1. The topics were put in a pedagogical sequence which we deemed appropriate to the general interests of children at this age. According to classroom conditions, students' interests, general ability and social situation, you may change the order.

2. If you do make such changes, write the reasons for and the results of such changes in an **Observation and Evaluation Notebook**. This note book will be of assistance not only to us, but also to yourself in your future teaching.

Teaching Strategy

1. General characteristics of the fundamental strategy of teaching to be applied in teaching of the Instructional Units II-V

is that of inquiry teaching. The steps to be followed may be: Guide your students face with a problematic situation which involve observation, then they will observe the event in actuality «observation», will collect data «phenomenological data» on which an informal class discussion may be developed, then the event will be reconstructed, thus duplicated in the classroom or in the lab by the student individually or by small groups composed of two or three students under experimental and controlled conditions «design of experiment»; another set of data will be collected by which some conclusions, tentative generalizations and mathematical relations are inductively deduced. The relationships established and generalizations arrived in these units may not be as cause and effect relations. They may be rather temporal and spatial relations at descriptive level. The relations established, ordinarily are not to be stated as mathematical formulae, but rather, whenever possible, will be expressed in graphical forms.

2. The experiments included in the instructional units (e.g. solar time, diffusion of amonia, hypo-salt, germination etc.) are carefully designed and tested by the members of SCDG. Necessary information and hints concerning them is given within the content of the unit considered. In some cases experiments are not fully explained in order to encourage the student to explore to complete them by his own resources. This way, it was hoped, the development of such abilities as designing an experiment, arriving at conclusions may be encouraged.

3. In some cases, the solution to specific investigation is purposefully omitted so that the students may propose their own solutions by which they can develop «ability necessary for framing plausible hypotheses». Suggested solutions pertaining to such cases are given in this guide.

Putting the Unit Into Practice

Since many of the learning activities involved in the instructional units take place outside of class (e.g., germination of seeds, solar time, life cycle of the fly), it will be necessary for students to

Appendix II-5

work after school individually or in small groups either at school or at home. The plan of action for these kinds of observations and experiments will be discussed and determined in class, and in general, the results of out-of-class observations and experiments will be discussed and evaluated in class, and general opinions will be arrived at. For these reasons, the amount of time allotted for in-class activities may be reduced. Based on this idea, the approximate breakdown of class hours for these units is given below:

	CLASS HOURS (Approximate)
Unit II — Change, Motion and Time	
Where is the Sun?	6-7
A. The Apparent Motion of the Sun	
B. How Can We Experimentally Reproduce the Conditions	3.5
C. How Can We Experimentally Reproduce the Conditions Appropriate to Our Observations?	2.5
D. Moving Bodies and Time Evaluation	1
Unit III — Change in Living Creatures and Time	3-4
A. How Much Do We Grow Each Year?	1
B. From Seed to Plant	3/4
C. The Life Cycle of the Common Fly	3/4

D. Change in Living Creatures Requires Time	1/2
Evaluation	
Unit IV — Change in Matter and Time	
The Diffusion of Gasses and Time	3-4
A. How fast is the Fragrance of Cologne Diffused?	1/2
B. How fast Ammonia Spreads Around?	1.5
C. Time is Needed for Gasses to Change position	1/2
Evaluation	
D. The Time Required to make lime solution cloudy.	1
E. Experiments with Hypo Salt.	1
F. Matter-to-Matter Reactions Require Time.	1/2
Evaluation	1/2
Unit V — Time and Change of Position.	2-3
A. The Time-Space Relationship	1/2
B. The Concept of Model	1/2
C. Units of Time	1/2
D. General Review of Units II-V	1/2
Evaluation	1/2

Units II-V (Total) 17-22

The class hours designated above may be changed as the results of the experimental teaching may deem necessary.

The Aims of Units II-V

The general aims of the units are helping the student:

1. To gain facts, principles and other relevant knowledge about change, motion and time in the universe, in our immediate environment including both living and non-living entities.
2. To develop a habit of critical and scientific thinking by means of solving problems related to the facts and principles covered in the content of the units by going through the steps of scientific inquiry for which the units provide ample opportunities, and which such activities as observation, data collection, hypothesis formulation, classification, synthesis and evaluation are included.
3. To develop positive attitudes toward science and its contributions to technological advancement and social development and to overcome the superstition especially related to our health and such natural phenomena as earthquake, flood, thunder, «rotten meat produces worms», «Earth is the center of universe», «Earth stays on the horns of a bull» etc.
4. To develop group way of thinking and behaving by means of having him participate in informal class discussions and activities related to «Suggested Student Projects» given in the text.

It should be noted that the knowledge that the students' acquisition of these units are fundamental but the realization of that end should be considered significant only when the knowledge acquired is appropriately used for the development of higher level cognitive abilities and attitudes which involve application of the knowledge, analysis, synthesis and evaluation of the phenomena faced or the product of science investigated. Therefore you should guide your students to participate, with his fullest capacity, in the scientific investigations organized around problems related to physical phenomena that the student is encountered in his daily life. Thus, **avoid long lectures** in handling your class rather give lectures and very short lectures only when a common difficulty arises in the class or when you evaluate the findings of the students in your class or when

you wish to give a summary based on the conclusions and generalizations that are reached through informal class discussions initiated by you and conducted under your guidance. The behavioral objectives that should be developed by your students are given with each unit included in this guide. Those are the behaviors that you will guide your students to develop by means of class and extraclass activities and those are the behaviors that you will test and measure at suitable intervals by means of tests that you will prepare and by the final test prepared for you to evaluate Units II-V. The results of these tests will not only help you to learn how much your students developed these behaviors but also to recognize what went wrong, if any, in your teaching.

Behavioral Objectives on «Where is the Sun?»

At The knowledge level:

— The Sun rises in the East and sets in the West.

— The Sun's motion is observable, and the route traced by this action is the orbit of the apparent motion of the Sun. This is our observation. Actually, the Sun is very nearly stationary and in fact this observation becomes meaningful with the acceptance of the revolution of the Earth around its axis.

— The points of the shadow of a pencil form a geometric curve.

— A graph showing the change in the length of a shadow through time, will at noon show a symmetrical curve resembling a parabola.

— The length of the arc traced by the observed motion of the Sun in the heavens, changes with the seasons. Thus in the northern hemisphere:

1. the arc is longest on the 22nd of June and shortest on the 22nd of December.

2. the arcs are equal on the 21st of March and 23rd of September.

— The position of the shadow is determined according to the northern side of the circumference. The position and length of the shadow change through seasons. The basic reason for this is that in the Earth's one-year revolution around the Sun, its axis is not perpendicular to its orbit, but is at an angle of approximately $66\frac{1}{2}$ degrees to it. Throughout the revolution of the Earth, its axis always remains parallel to itself. For this reason, the arcs traced by the Sun in the heavens seem to slip away from each other, remaining parallel, through the seasons.

— A moving body can not be in two places at the same time.

Concepts:

At the conclusion of this part of the unit, as a result of observations, experiments, and discussions, it is expected that concepts will be developed by students. Due to individual differences, there may be differences in the level of development. Time, position, time-position orbit, source of light, rotation, axis, height, day, apex, observation, experience, experiment, graph, curve, error, model are the fundamental concepts to be developed by the students.

Observations:

i. The points of the Sun's rising and setting will be observed from the same place, at specific time intervals (1 month each) three times.

ii. What is the position of the shadow in relation to the Sun? (To be observed in the morning, at noon, and in the evening.)

iii. How do the position of the Sun and the length of its shadow change, as observed in the morning, at noon, and in the evening?

iv. The situation given in section D will be observed by students outside of school as a homework, and will be discussed in class, dwelling on individual differences.

Hypotheses:

The answers to be given by students to the questions on this unit in the textbook are their hypotheses. These answers will indicate the students' ability to frame hypotheses. In order to develop this ability it is useful to ask questions on models other than those in the text. Two important hypotheses related to this topic are:

1. In Experiment III, the Earth is stationary and the Sun revolves around it, (according to our observation), and
2. In Experiment IV the Sun is stationary, and the earth revolves around it while rotating on its own axis. (In accord with our thinking; can be tested in laboratory).

Analysis:

- a. The position and length of the shadow changed through time. Therefore there is a motion.
- b. It is possible to determine the length of the shadow at a given time and vice-versa. Therefore, time is expressed through change.
- c. It is possible to explain the relation between the change in the shadow and time by means of the above assertions and other hypotheses.
- d. On the Earth, while at one place the Sun is rising, at another place it has already risen, e.g. at the moment it is noon elsewhere. This means that time depends on place.
- e. If at any given moment, a body is at one place, and if at another moment it is at another place, this means that this body is in motion.

Synthesis:

- a. Motion is relative.

b. We can construct a sun-dial which will be accurate in all seasons for the place in which we live. This sun-dial will not be accurate for any other place.

c. A model is the most suitable means of representing all of the events mentioned in the hypotheses, in the most complete and realistic way.

d. The scientific definition of time is expressed through the Earth's rotation on its axis.

Evaluation:

Compare the curves of the points of the shadows in Experiments II, III, and IV. Also, compare the various curves of the points of the shadows obtained in Experiment II among themselves. Do the same thing for the curves in Experiment IV. what do you think about such comparisons?

Experiments:

Experiment II — Throughout the duration of the experiment, students are not to make the slightest change in the position of their desk, pencil, and paper. The lengths of the shadows can be measured from the point determined by the pencil with a margin of error of 2 mm. In completing the shadow direction column in chart II, too much sensitivity should not be expected. As we can determine the north by means of a compass, so the direction of the shortest shadow will almost show us the north. One way to find the direction of the shortest shadow is as follows: At any time before noon, let us say at 10 a.m., we mark the point of the shadow. Taking a pencil-mark reference point as the center, we draw an arc which passes through the point. After noon, when the point of the shadow falls on this arc, we mark the point. We join the two points on the arc, and find their mid-point. Connecting this mid-point with our point of reference (the center) will show us the true north. If we add one-half of the difference between these two times to 10 o'clock,

we will find the time of the shortest shadow. As seen in diagram 2, this time occurs between 11:45 and 12 a.m., and according to the vertical line which passes through this point, the curve is a symmetrical one. Using this curve as a sun-dial, we should remember, that aside from the instance of the shortest shadow, the same length of shadow will indicate two times: one before noon, and one afternoon.

Appendix III

**SAMPLE ITEMS FROM THE TEST MEASURING THE
ACHIEVEMENT OF THE EXPERIMENTAL GROUP THAT
STUDIED THE UNITS ON «CHANGE, MOTION
AND TIME»**

- I. **The Purpose of the Test.** Main objective of the test is to provide some reliable data on the degree of assimilation of the experimental group of the curriculum materials developed around change, motion and time concepts in an unified form including physics, chemistry, biology, astronomy and earth sciences which were used to be taught as independent disciplines of study at Turkish Jr. High Schools.
- II. **The Experimental Group.** The experimental group was composed of 20 elementary school graduates who volunteered to participate in the experimental teaching of unified science curriculum materials that are developed. Their chronological age average was 11 years 4 months. The group involved in 24 hours of intensive teaching conducted at Ankara Namık Kemal İlkokulu under the supervision and guidance of the project.
- III. The Test included 48 multiple choice items. Although no time limit was set, the group finished the test in 100 minutes. Among the 48 items, only 4 is intended to measure the know-

ledge learning. The rest aimed at measuring levels of comprehension, translation, interpolation, extrapolation, application and analysis abilities of the students.

- IV. The mean score of the group was 32.40. One student scored as high as 46, two 42, and others between 23-46 having a range of 23.
- V. The same test was administered to a small group of science seniors of METU. Although their group average was a bit higher (33.28) than that of the experimental group, the highest score achieved by the experimental group was considerably higher than that of the METU group.

SAMPLE TEST ITEMS

A. Item aiming to measure knowledge learning:

e.g. What is the celestial position of the Sun at noon in the northern hemisphere?

- A. South B. North C. East D. West

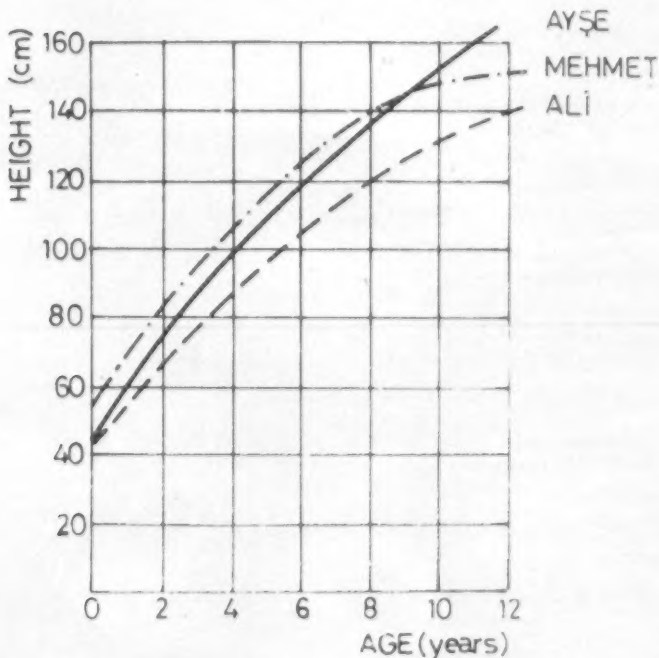
B. Items aiming to measure the ability to apply:

e.g. Keeping other conditions constant, if the shape of the Earth were a cylinder rather than a sphere which of the following would take place?

- A. With respect to our point of observation, points of sun rise and sun set would change by time.
- B. Sun shadows of a particular object would stay constant throughout a day.
- C. No relations could be established between sun shadows and time.
- D. On the two points with equal latitude, the lengths of the sun shadows of the two identical objects would be equal when observed at identical local times.

e.g. Keeping the shape of the earth as it is, if the plane of rotation of the earth becomes perpendicular to the rotation axis of the earth, how would the shadow curve change with change of seasons?

- A. The arms of the shadow curve would converge in summer.
 - B. The arms of the shadow curve would converge in winter.
 - C. The curve would be the same as before.
 - D. The curve would change irregularly.
- C. Questions aiming to measure ability to interpret graphs:
e.g. The graph below shows the heights of Ali, Mehmet and Ayşe as recorded in different years. Answer the questions (14-17) by means of knowledge given in the graph.



At birth

- A. Mehmet, Ali and Ayşe had the same height.
- B. Mehmet was taller than Ali and Ali was taller than Ayşe.
- C. Ali was taller than Mehmet, and Mehmet was taller than Ayşe.
- D. Ali was as tall as Ayşe yet Mehmet was the tallest of all.

At what age Mehmet, Ali and Ayşe have the same height?

- A. At Birth.
- B. At the age of 10.
- C. At the age of 12.
- D. At no age.

Who is the tallest till the age of 10?

- A. Mehmet B. Ayşe C. Ali D. Can't tell.

When Ayşe's height was 130 cm., how tall was Mehmet?

- A. He was 135 cm.
 - B. He was 125 cm.
 - C. He was 130 cm.
 - D. Can't we determined.
- D. Questions aiming to measure the ability of translation from data into a graph or vice-versa:

e.g. Below is given the number of enrollments of a school in different years. Which of the graphs represent the situation?

Appendix III-5

Years

1965

1966

1967

1968

1969

Enrollment

80

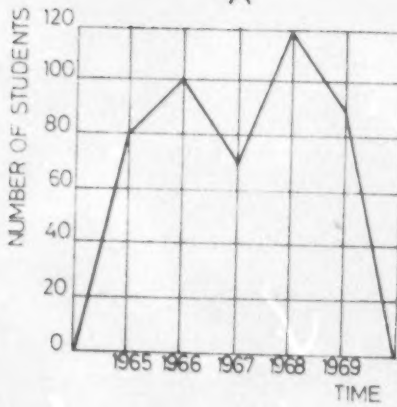
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70

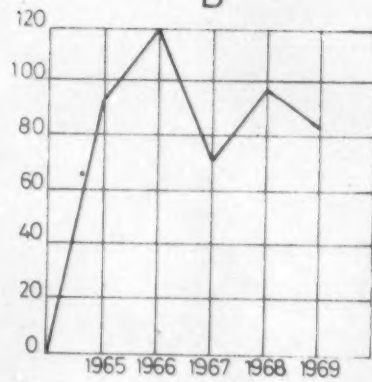
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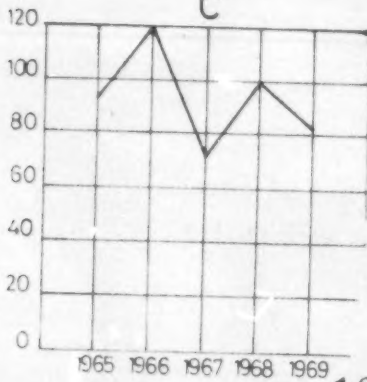
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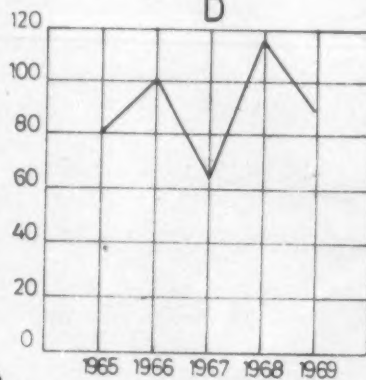
B



C



D



APPENDIX

**THE LIST OF MEMBERS WHO CONTRIBUTED TO
THE CURRICULUM DEVELOPMENT ACTIVITIES OF
SCDG***

- Assoc. Prof. Dr. A. Kemal Özinönü, Project Director, Chairman of Department of Education, Faculty of Arts and Sciences, M.E.T.U.
- Assoc. Prof. Dr. Namık K. Aras, Chemistry Group Member, Department of Chemistry, Faculty of Arts and Sciences, M.E.T.U.
- Assist. Prof. Dr. Namık K. Tunalı, Chemistry Group Member, Department of Chemistry, Faculty of Arts and Sciences, M.E.T.U.
- Assist. Prof. Dr. İmre Usseli, Member of Physics Sub-group, Department of Theoretical Physics, Faculty of Arts and Sciences, M.E.T.U.
- Assist. Prof. Dr. Mehmet Aydın, Member of Physics Sub-Group, Department of Experimental Physics, Faculty of Arts and Sciences, M.E.T.U.
- Assist. Prof. Dr. Bedri Süer, Mathematics and Astronomy Group Member, Dept. of Mathematics, Faculty of Arts and Sciences, M.E.T.U.
- Assist. Prof. Dr. M. Fuat Turgut, Member of Evaluation Sub-group, Dept. of Education, Faculty of Arts and Sciences, M.E.T.U.
- Assist. Prof. Dr. Adnan Erginel, Member of Evaluation Sub-group, Dept. of Education, Faculty of Arts and Sciences, M.E.T.U.

* With their academic titles at the time of their participation.

Mustafa Öktem Member of Biology Sub-group, Teacher of Biology, Science Lycée, Ankara.

Faruk Aysu Member of Biology Sub-group, Teacher of Biology, Science Lycée, Ankara.

In addition to the above list of members, several people have made significant contributions to the project in the status of technician, assistants and Laboratory Supervisors who worked on a part time basis.

Author Index

- Alkin, Wilford M., 32
 Aliport, G.W., 55n
 Anderson, V.E., 14
 Angell, George W.Jr., 55
 Arseven, Ali Doğan., 70
 Atkin, Myron., 35
 Awkermann, G.L., 44
- Bane, Marry J., 17
 Baysal, Bahattin., 65
 Bauchamp, M., 16
 Blackwood, P.E., 96, 102
 Bloom, Benjamin S., 25, 29, 32
 45, 69, 75, 88
 Brandwein, P.F., 101, 102
 Brooks, W.O., 58
 Bruner, Jerome S.,
 Burkman, Ernest., 95
 Burnett, Will R., 100
- Campbell, C.V., 29
 Çilenti, Kamuran., 65
 Cohen, M.R., 29
 Cox, D., 97
- Dewey, John., 14, 16, 29, 49
 Dittmer, Karl., 97
 Dull, C.E., 58
 Duyser, Lucille., 36
- Ertürk, Selahattin., 29
- Finlay, G.C., 38, 39, 41, 42
 Fiesca, Micheal. 97
 Forbes, G.L., 44
 Frey, F.W., 55n
- Gatewood, C.W., 31
 Gervers, V., 95
 Good, Carter V., 14
- Goodlad, J.I., 37-41
 Graham, C.C., 95
 Grim, P.R., 14
 Grobman, H., 29, 39, 40, 42, 100
 Gruhn, W.T., 14
- Haber Schaim, Uri., 36
 Hastings, J.T., 69
 Hyman, H.H., 55n
 Herbart, J., 13
 Holton, Gerald., 102
 Hon, W., 44
 Hurd, J.R., 95
- Jenks, Christopher., 17
- Kant, Emmanuel., 13
 Karamanoğlu, K., 65
 Kessler, Oreon., 29
 Koch, R., 34n
- Lane, Howard A., 16
 Lee, Dorris M., 15
 Lee, Eugene., 31
 Lee, Murray. J., 15
 Lindsey, C.A., 55
- Madaus, F.G., 69n
 Marshall, Stanley J. 69, 70
 Mayor, J.R., 36, 96, 97
 Meyer, Adoph E., 14
 Metcalfe, H.C., 58
 Moise, E., 35
 Monroe, W.S., 20
 Morrison, H.C., 15
- Nagel, Ernest., 29
 Newton, Isac., 36n
 Novak, B., 95
- Oral, 65, 66

Olçun, M., 65
Özinözü, A. Kemal., 32, 43, 44, 65,
66, 71, 72, 74, 95

Payashoğlu, A., 55n
Pestalozzi, 14
Pieper, C.J., 16
Pimental, G.E., 35, 39, 41, 62, 64, 65

Rousseau, J., 14
Rutherford, F.J., 29, 107
Richmont, Kenneth W., 31

Seaborg, Glenn T., 43
Schlesinger, A.B., 43, 44
Shores, Harlan., 15, 29
Showalter, V., 97
Smith, B.O., 15, 16., 29, 96
Sorokin, Pitirim A., 18
Stanley, W.O., 15, 29

Strong, L.E., 35, 40, 41
Sund, R.S., 96
Swartz, Clifford E., 35
Şenvar, Cemil., 67

Taner, Tuğrul., 65
Thelen, Howard E., 24, 29, 69
Trowbridge, L.W., 96n
Tyler, R.W., 29, 32, 44, 45, 69
Turgut, M. Fuat., 75-79

Van Deventer, W.C., 36
Varış, Fatma., 88
Vernon, P.E., 55n

Washton, Nathen S., 100
Watson, Fletcher G., 96, 102
White, Harvey E., 58-60

Yıldırım, Cemal., 71, 72, 74

Subject Index

- AAAS (American Association for the Advancement of Science): 35, 36, 40, 97
- Academic: standing, 35; aptitude, 42; learning, 51; track, 51
- Achievement: 72, 76, 77
- Activity curriculum: *See* Curriculum
- Adjustment: 48-57; individual, 48; social, 50, 57
- Adolescent: problem, 54; psychology, 56; needs, *See* Individual needs.
- AEC (Atomic Energy Commission): 44
- Aims: 39, 52, 82, 86, 87 *See also* Objectives; of Jr. High School, 85-88
- Alphabet courses: 31, 34-36, 40, 43; movement: 46, 50, 60, 62, 63-65, 68, 78, 80, 82, 96 *See also* Curriculum.
- Appraisal: 21, 41; of curriculum, 41, 42, 100-102; of curriculum movement, 69-80
- Allotted time: related to science, 63, 64, 134
- Alternatives in culture: 18, 25 *See also* Culture.
- Assessment: 25, 27-30, 55, 57
- Attitudes: 21, 88; scientific, 88
- Bahçelievler Experimental School (Bahçelievler Deneme Lisesi): 55
- Basic Mathematics: 78
- Behavior: patterns of, 22; behavioral objectives; *See* Objectives.
- Broad - fields curriculum: *See* Curriculum.
- Beşiktaş Middle School (Beşiktaş Orta Okulu): 53, 54
- CBA (Chemical Bond Approach): 35, 36, 40, 42
- CHEMS (Chemistry - An Experimental Science): 29, 35, 39, 41, 62, 64, 65
- Child-centered movement: 32
- Classroom strategy: 33; *See also* Teaching Strategy
- Clearinghouse Annual Reports: 36
- Cognitive operations: 72
- Common learnings: 69
- Concept: 89
- Content: deductive aspects of 66; of instruction, 15; order of, 37, 65, 95; organization, 34, 38, 40, 44, 47, 48, 50, 63-65, 68; sample of, 90-94; selection, 24, 88, 89; shortcomings, 78
- Control group: 55
- Consistency of objectives: *See* Objectives
- Culture: 16, 18-25, 86; alternatives in, 18, 25; and curriculum 17, 18; elements of, 17; cultural change and educative process, 21, 22; impurities of, 22; specialties of, 18; transition of, 18; transmission of, 17; universals of, 18, 86; values of, 18
- Curricular: movements, 46, 49; activities, 55
- Curriculum: A sample of, 90-94; activity, 96; assessment, 22; basic movements, 9-11, 31; broad-fields, 52, 53; chain relation in, 35; construct of, 22-23; consultants, 84; defined, 14-19; development, 16, 21, 24, 28-30,

Subject Index

- 35, 50, 55, 61, 63, 68, 82, 83; development project, 36, 83; dynamics of, 24; educative process and, 16-19; experiment, 50, 53, 75; experimental appraisal of, 84, 85; functions of, 19; goals of, 47; innovations, 32, 65-69; integration in science, 36, 51, 69, 82, 83, 85; in science, 36, 69, 82, 83, 85; materials, 29, 38, 52, 57, 58, 62, 67, 68, 84, 97, 101; modification, 43; multi-track, 51; new directions, 42-47; package, 37, 41; project analysis, 84; revision, 24, 28; subject, 96; from subject-matter to, 19-23; science, 29, 30, 33-35, 39, 42, 43, 45-47, 50, 51, 52, 55, 56, 61, 63, 68, 75, 78; unified, 97; theory of, 32; validation, 32
- CUSE (Center for Unified Science Education): 97
- Data, phenomenological: 99
- Deduction: 68; deductive, 47, 66
- Development and growth: 21, of scientific thinking, 34 *See also* Scientific Thinking.
- Discipline: 16, 38; of science, 42, 47, 49, 50, 52; of study, 13, 20-24, 26, 27, 36, 55, 56, 86; centered curriculum, 38; *See also* Curriculum.
- DPT (Devlet Planlama Teşkilatı - Turkish State Planning Organization): 47
- Drop-outs: 85
- Ecology: 44
- Education: 17-19; aims of, 25; as manpower development, 21; central, 46; defined, 16-18; educational engineering, 24; elementary science, 36; formative evaluation of, 25, 27-29; functions of, 14, 24, 28; inequalities of, 86; policy of, 46; process of, *also* Educative Process, 15-21, 24; reforms of, 19; socializing functions of, 21, 86; summative evaluation of, 25, 29; technology of, 56
- Educational Testing Service: 42
- Educative process: *See also* Process of Education, 16-19
- Effective learning: 21
- Eight Year Study: 32, 33; movement, 31-35, 38, 47
- Elementary astronomy: 35
- Elementary education: 15, graduates of, 85
- Encyclopedia of Educational Research: 20
- Entrance examinations: 26
- Environmental, impacts: 44, studies, 44
- ESS (Elementary Science Study): 35, 68
- Evaluation: 25-29, 68; and objectives, 25-29; formative, 25, 27-29, 68; of instructional units, *See* Unit; instruments of, 53; notebook, 97; objective, 58; summative, 25, 29, 53, 68
- Experience, goal directed: 15
- Experiment: 50-60, 75-80; Ankara Bahçelievler Lycée, 50, 55-57; design of, 99; Istanbul Atatürk Girls' Lycée, 50, 52-55, 58; kits, 37, 41, 84; multi-purpose high school, 50; pilot lycées, 75-80; sporadic, 50-64; teaching physics by films, 50, 57-60
- Experimental: appraisal of curriculum, 38, *See also* Curriculum; design, 40; group, 53-55, 58, 100, 102; schools, 32, 34, 35, 50-60, 75-80; teaching *also* trial teaching, 41, 84, 100-102; validation, 32

Subject Index

- Feedback: 27
- Field trip: 14
- Florida State University: 61
- Follow-up studies: 38
- Foreign specialists, *also* experts: 55, 65, 68
- Ford foundation: 55, 58, 61, 62
- Goal: of a course, 68; of curriculum, - *See* Curriculum; of education, *See* Education; ultimate, 68, 86 *See also* Objective.
- Group ways of thinking: 16, 87, 98
- Guidance: 55, 65; of learning activities, 40
- Herbartian formal steps: 48
- Hypothesis: formulation of, 87; testing of, 40, 87
- ICA (International Cooperation Agency): 58
- Individual: differences, 28; needs, 22
- Information, functional: 87
- Innovative activities: 65
- Input: 18, 19, 26, 27, 88, 101; background, 22; behavior pattern of, 18; capacity, 22; characteristics, 28, 88; innate capacities of, 28, 101; maturity level of, 25; quality of, 29
- Inquiry: 66, 87, 96; science as, 66; scientific, 87
- Instruction: 14; effectiveness of, 28; process of, 47, 50, 56, 57, 63; science, 72; units of *See also* Instructional units, 47, 49, 52, 53, 56, 57, 65, 68, 82, 83, 85, 95, 97, 100
- Instructional process: *See* Process; effectiveness of, 27; objectives of, 29
- Interaction: 17; bilateral, 27; individual-society, 52; intensity of, 29; man-environment, 43; optimization of, 17, 23, 26; pattern of, 18, 19, 26-29; system of, 21, 27; unilateral, 26
- Interest: 66, 87, 88
- IPAT, High School Personality Questionnaire: 70, 71
- IPS (Introductory Physical Science): 36, 78-80
- Integration: 51, 52, 90, 97, *See also* Unification; integrated, 55, 65, 83, *See also* Curriculum.
- Investigation: 89, 90
- Junior H.S.: 52, 82-86, 90, 95
- Know-how: 18
- Knowledge: learning of, 20; levels, 72; organized body of, 20, 22
- Laboratory: activities, 39, 67, 83; guide, 37, 41, 66; kits, 84
- Laws of nature: 34
- Learner: 21, 23
- Learning: activities, 40, 69; by doing, 67; effective, 21; ineffective, 78; experience, 14, 24, 27; by experimenting, 37; group, 21; mastery 67, 80; Power Test *See* Test.
- Lise müfredatı: 20
- Lycée: Ankara Atatürk, 58; Ankara Girls, 58; Ankara Science, 50, 61-68; curricula, 20; Nişantaşı Girls, 54, 55
- Man-environment: equilibrium, 31, 43; interaction *See* Interaction; relations, 36; technology interaction, 81
- Manpower demands: 19
- Marine science: 44
- Maturity level: 23
- Measurement: 53, 67
- Measuring and evaluating: 23
- MEB (Ministry of Education): 73, 83, 84; supervision of, 84

Subject Index

- Method: 21; of inquiry, 40; of science, 33
- Middle East Technical University: 62, 102
- MIT (Massachusetts Institute of Technology group): 35, 36
- Modern Physics: 58, 59, 80
- Moral education: *See* Education.
- Motivation: lack of, 78, 80
- MRP (Mediterranean Regional Project): 44
- National Education Convention: 50, 52
- National priorities: 24, 43
- Natural and Physical Science: 51, 53
- NEA (National Education Association): 32, 33
- Needs: 21, 22, 25; group, 21; individual, 21, 22, 25
- Newton mechanics: 37
- Nişantaşı Girls Lycée: *See* Lycée.
- NSF (National Science Foundation): 43
- NSSE (National Society for the Study of Education): 29, 32, 87
- Objectives: 51-53, 63, 67, 68; as aims, 32, 52, 82, 86; as output behaviors 25, 28, 88; attainment of, 25; behavioral, 19, 45, 82; consistency of, 25; desirability of, 24, 25, 28; examples of, 98, 99; formulation of, 44; measurability of 25, 29; plausibility of, 28; as targets, 16, 23, 25
- Ocean studies: 44
- Order: of content, 37; of topics, 39
- Output: 18; behaviors, 25, 28, 88; qualifications, 25; quality of, 19, 25, 26, 28, 82
- Pattern: of behavior; of responses, 22; *See* Behavior.
- Pedagogy: 13, 14, 20
- Pilot high school: 75
- Pilot lycée: experiment, 75, 78; students, 80
- Plan: 23
- Plausibility: 78
- Power of learning: 70
- Probing the Physical World: 95
- Problem solving: 42, 57, 69; ability, 37, 40; and reflective thinking, 33; effective use of, 40; skills, 88, 95
- Process: of curriculum development, 69; educative, 26; of education, *See* Education; of inquiry, 40, 45; instructional, 27-29, 32; of interaction, 17; of science, 39; targets of, 26; units of instruction, 33
- Profession: 14
- Professionalized: 18
- Programmed instruction: 29
- Progressive Education Association: 31
- Project: individual or group, 66
- Project Physics Curriculum: 29
- Proximity principle: 56
- Pseudo-achievement: 78
- PSSC (Physical Science Study Committee): 35, 38-42, 62, 64, 65, 78-80
- Psychologist: 21
- Reference system: 18
- Relations: spatial-temporal, 52
- Response: after process, 22; before process, 22; system development, 23
- Russian Sputnik: 38. *See also* Sputnik era.
- Rutherford atomic model: 37
- SCDG (Science Curriculum Development Group): 83-89, 95-97, 102; the list of, 147
- School: comprehensive, 50, 52; experimental, 50-52, 54; multi-

Subject Index

- purpose, 52; normal, 51; technical-vocational, 51
- School science education policy: 78
- Science: history of, 33; as inquiry, 66; methods of, 86; a process approach, 97; process of, 35; projects, 40; shy students, 39, 101; syllabus, 65; track, 74, 78
- Science Education Development Commission: 62
- Science Lycée Project: 62-64; 69, 75; evaluation of, 70-73, 75
- Scientific: experiments, 33; inquiry, 34, 39, 67, 87; attitudes, 88; investigation, 65; literacy, 97; manpower, 38; methods, 33, 51; observation, 96; phenomena, 51; principles and concepts, 33-34, 89, 90; reasoning, 36; themes, 82; thinking 68, 72-74
- Scientific and Technical Research Council of Turkey: 62
- SCIG (Science Curriculum Improvement Group): 35
- Secondary school science: curriculum development, 80, 81; teaching, *See* Teaching.
- Sensate: 18
- SMAG (School Mathematics Study Group): 35, 62
- Social: change, 16, 24; direction, 15; institutions, 17; reconstruction, 25; stability, 16, 18; structure, 17
- Socialization: 18
- Socializing process: 15
- Socially phenomenological: 44
- Societal demands: 16, 19, 25, 46
- Socio-economic: conditions, 72, 74, 86; differences, 73; level, 74; strata, 55
- Sputnik era of science: 42, *See also* Russian Sputnik.
- SSI (State Statistical Institute): 85
- Student: council, 14; high-aptitude, 42
- Subject-matter: 16, 19-25, 29, 43, 49, 52, 56, 66, 82, 83; boundaries of, 41; criteria for selection, 88, 89; defined, 20; mastery of, 74; modification of, 43; science, 74; transformation of, 82; validity of, *See* Validity.
- Subject specialist: 21
- Supervision: 14
- Supervisor: 21
- Survey course: 44
- Syllabus: 20, 64, 65, 78, 80; content organization in, 65; new science and mathematics, 75; organization, 67; of physics course, 64; of science, 48, 63, 66
- Synthesis: *See also* Integration; generalization-centered, 57; interdisciplinary, 57; topic-centered, 57
- Targets: *See* Objectives.
- Taxonomical behaviors: 41; *See also* Behaviors.
- Teacher's guide: 37, 40, 41, 47, 84, 97-100, 101, 102; sample of, 129, 141
- Teacher's qualification: 72, 74, 78
- Teaching: classroom, 79; inquiry, 96; learning process, 40; learning units, 40; method of, 57, 59; multi-media, 57; process of, 47; remedial, 100; science, 72-74; secondary school, 73; strategy, 37, 40, 99; trial, 29, 67, 83, 100, *See also*, Experimental teaching.
- Technical school: *See* School.
- Test: ability, 33; achievement, 33, 41, 42; attitude scores, 42; conventional aptitude, 41; Educational Institutes General Achievement, 54; Learning Power,

Subject Index

- 70, 71, 73, 74; Middle School Graduates General Achievement, 54; Otis Beta, 54; Otis Gamma General Ability, 54; Primary School Graduates' Achievement, 54; a sample of unit, 142-146; science achievement, 73; scientific thinking ability, 72-74; social sensitivity, 33; Thurston's Basic Abilities, 54; unit, *See* Unit.
- Testing of hypothesis: 40
- Test and Research Bureau: 53
- Thinking: aspects of, 33; effective, 86; group ways of, 87; pattern of, 34; scientific, 83, 87
- Time - lag: 17
- Track system: 26; *See also* Curriculum.
- Training: in-service, 48, 62, 63, 84
- Truth: of faith, 18; of reason, 18
- Turkish Ministry of Education (M.E.B.): 20, 73, *See also* M.E.B.
- Unit: allocation of, 95; evaluation of, 100; instructional, *See* Instruction; organization of, 53, 57, 83, 95; as problem solving, 97, 98; samples of, 117-128; tests, 58, 60, 97, 101, 102; unified science, 97
- University of Maryland: 36
- Validity: subject-matter, 23, 24; targets or goals, 23, 24
- Village Institute: 51
- Vocational school: *See* School.
- Workshop: 62, 84